U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT - ALASKA
DIVISION OF MINERAL RESOURCES
BRANCH OF MINERAL ASSESSMENT

ALASKA MARITIME NATIONAL WILDLIFE REFUGE OIL AND GAS ASSESSMENT

by

Ronald Teseneer

Aden Seidlitz

James Borkoski

September 1988

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (cont.)

EXECUTIVE SUMMARY

The area of the Alaska Maritime National Wildlife Refuge (NWR) has generally attracted little oil or gas exploration interest. No wells have been drilled within the refuge, however, several have been drilled near refuge lands. This study of the hydrocarbon occurrence potential of Alaska Maritime NWR indicates that the refuge has lands with high, moderate, low, and no potential. Lands with high potential total about 260,000 acres, or about 5 percent of the refuge. Those lands with moderate potential total approximately 50,000 acres, or about 1 percent of the refuge. The lands with low potential total about 90,000 acres, or about 2 percent of the refuge. Ninety-two percent of the refuge, or 4.4 million acres, has no potential for hydrocarbon occurrences. All refuge lands were determined to have either low or no development or economic potential for development through the turn of the century. For a detailed listing of the refuge lands as well as their hydrocarbon occurrence and development potential, see Appendix D.

ILLUSTRATIONS

ILLUSTRATIONS (cont.)

LIST OF TABLES

INTRODUCTION

This report will provide an oil and gas resource assessment of the Alaska Maritime National Wildlife Refuge (NWR) to be included as part of the "comprehensive conservation plan" for the refuge as mandated by Sections 1008 and 304(g) of the Alaska National Interest Lands Conservation Act (ANILCA). The U.S. Bureau of Land Management (BLM) is conducting the resource assessment at the request of the U.S. Fish and Wildlife Service (FWS) as set forth in a Memorandum of Understanding between the FWS and BLM (Appendix A).

This assessment will:

1. Identify areas of different hydrocarbon resource potential.

2. Illustrate and discuss a hypothetical development scenario within Alaska Maritime National Wildlife Refuge.

3. Present an economic assessment of oil and gas production from the Alaska Maritime National Wildlife Refuge.

The Alaska Maritime NWR contains approximately 4.9 million acres. It extends from Forrester Island in southeast Alaska west across the Aleutian Islands to Attu Island, and north to the vicinity of Barrow (see figure 1). Approximately 3,000 headlands, islands, islets, and pinnacles are included within the refuge.

The Alaska Maritime NWR has five units, the Chukchi Sea Unit, the Bering Sea Unit, the Aleutian Island Unit, the Alaska Peninsula Unit, and the Gulf of Alaska Unit. The Chukchi Sea Unit contains 200,000 acres and extends from the Bering Strait northward to Barrow (figure 2). The Bering Sea Unit contains 200,000 acres and extends from the Bering Strait south to the Pribilof Islands (figures 3, 4, and 5). The Aleutian Islands Unit contains 3.3 million acres and extends from Unimak Island west to Attu Island (figures 6, 7, and 8). The Alaska Peninsula Unit contains 700,000 acres and extends along the south side of the Alaska Peninsula from the tip of the peninsula to the Katmai National Park Boundary (figure 9). The Gulf of Alaska Unit contains 500,000 acres and extends from Kodiak Island to Forrester Island (figures 10, 11, and 12).

DESCRIPTION OF GEOLOGY

Physiography

The topography of the Alaska Maritime NWR ranges from low barrier islands to rocky cliffs along the Chukchi Sea coast, to the rugged volcanic mountains of the Aleutian Islands, to the gently rounded Forrester Island of southeastern Alaska. Alaska Maritime NWR lies within all four of the major physiographic divisions within Alaska: the Interior Plains, the Rocky Mountain System, the Intermontane Plateaus, and the Pacific Mountain System (figure 13).

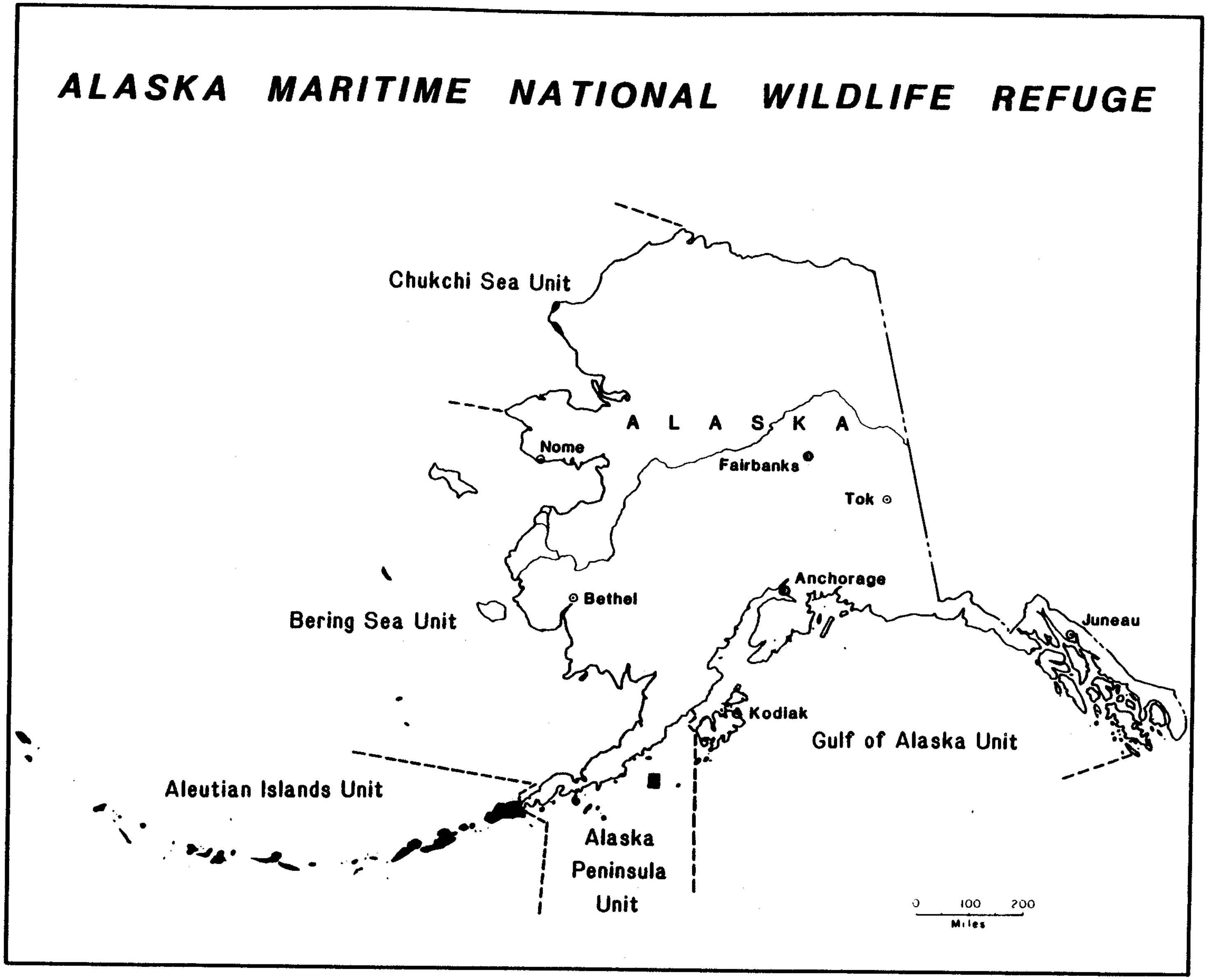


Figure 1. Location map of the Alaska Maritime NWR.

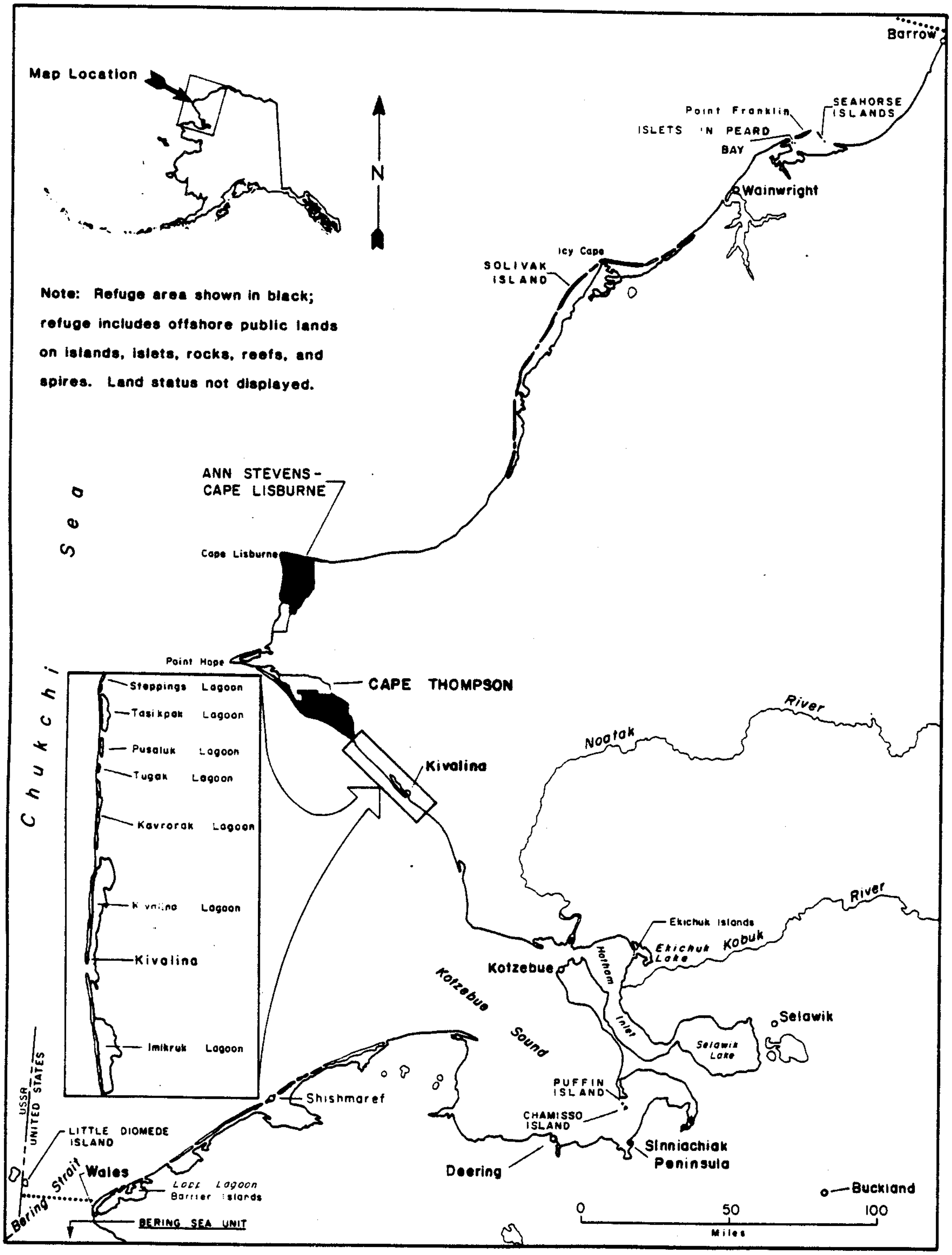


Figure 2. Location map of the Chukchi Sea Unit.

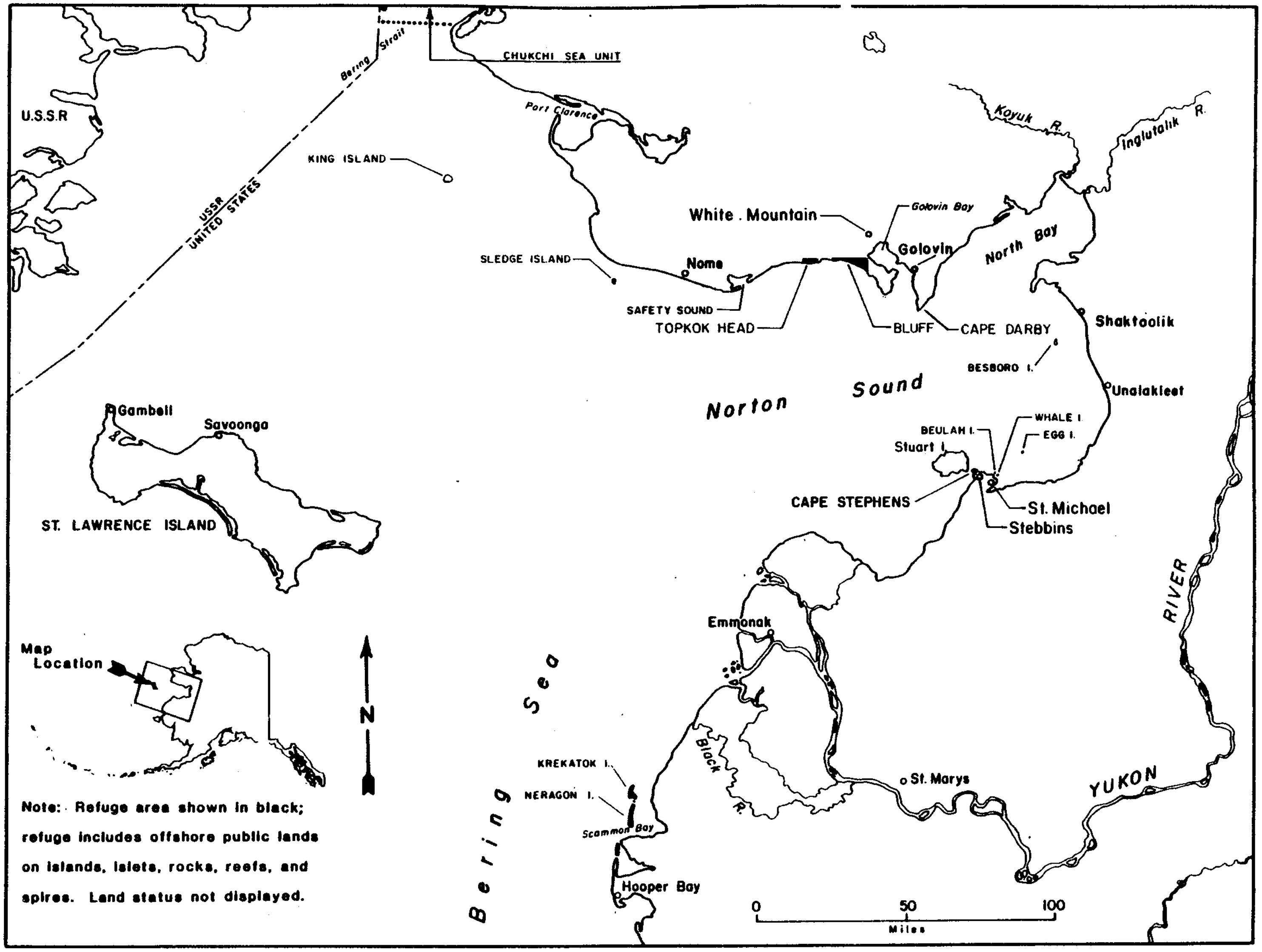


Figure 3. Location map of the Bering Sea Unit, map 1 of 3.

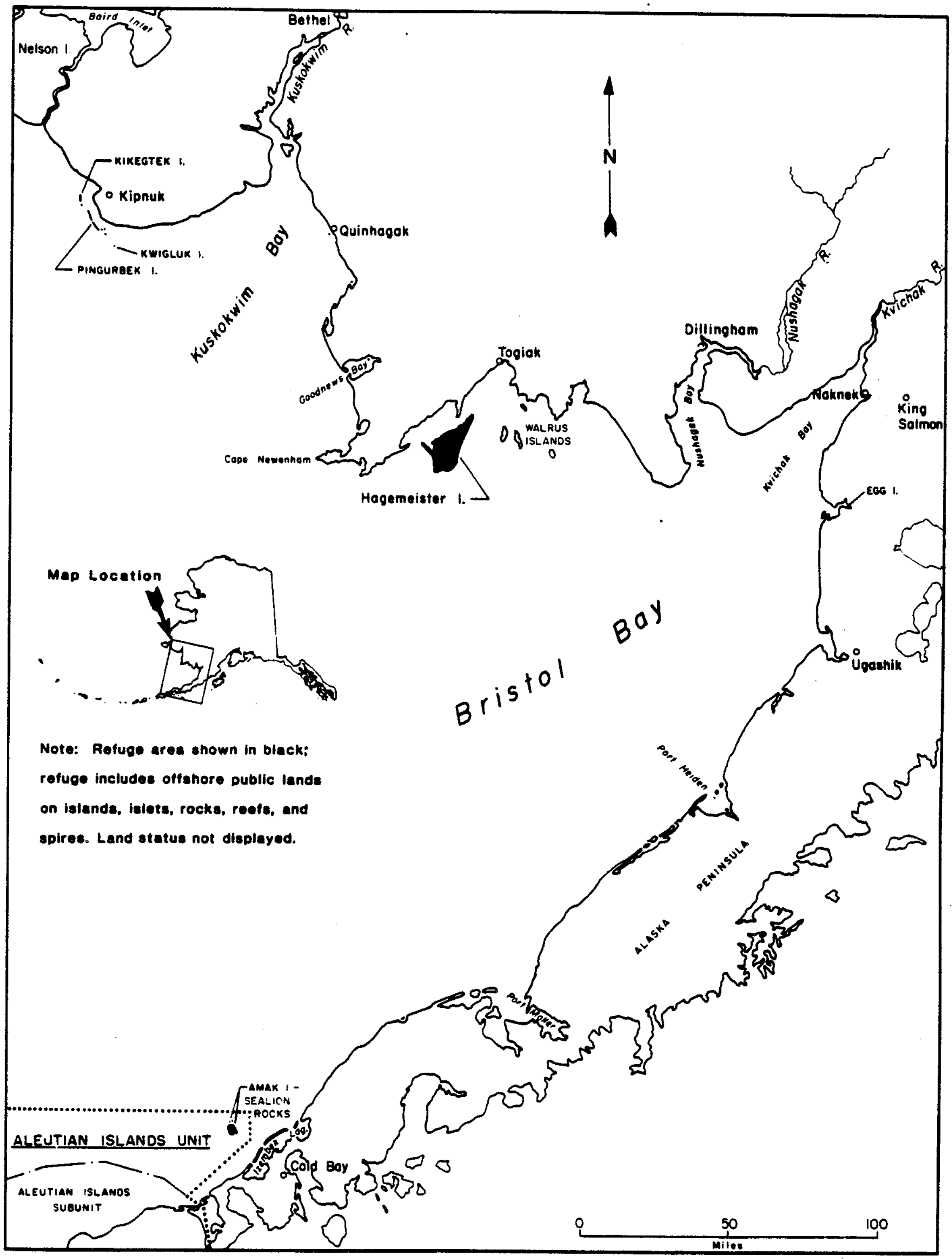


Figure 4. Location map of the Bering Sea Unit, map 2 of 3.

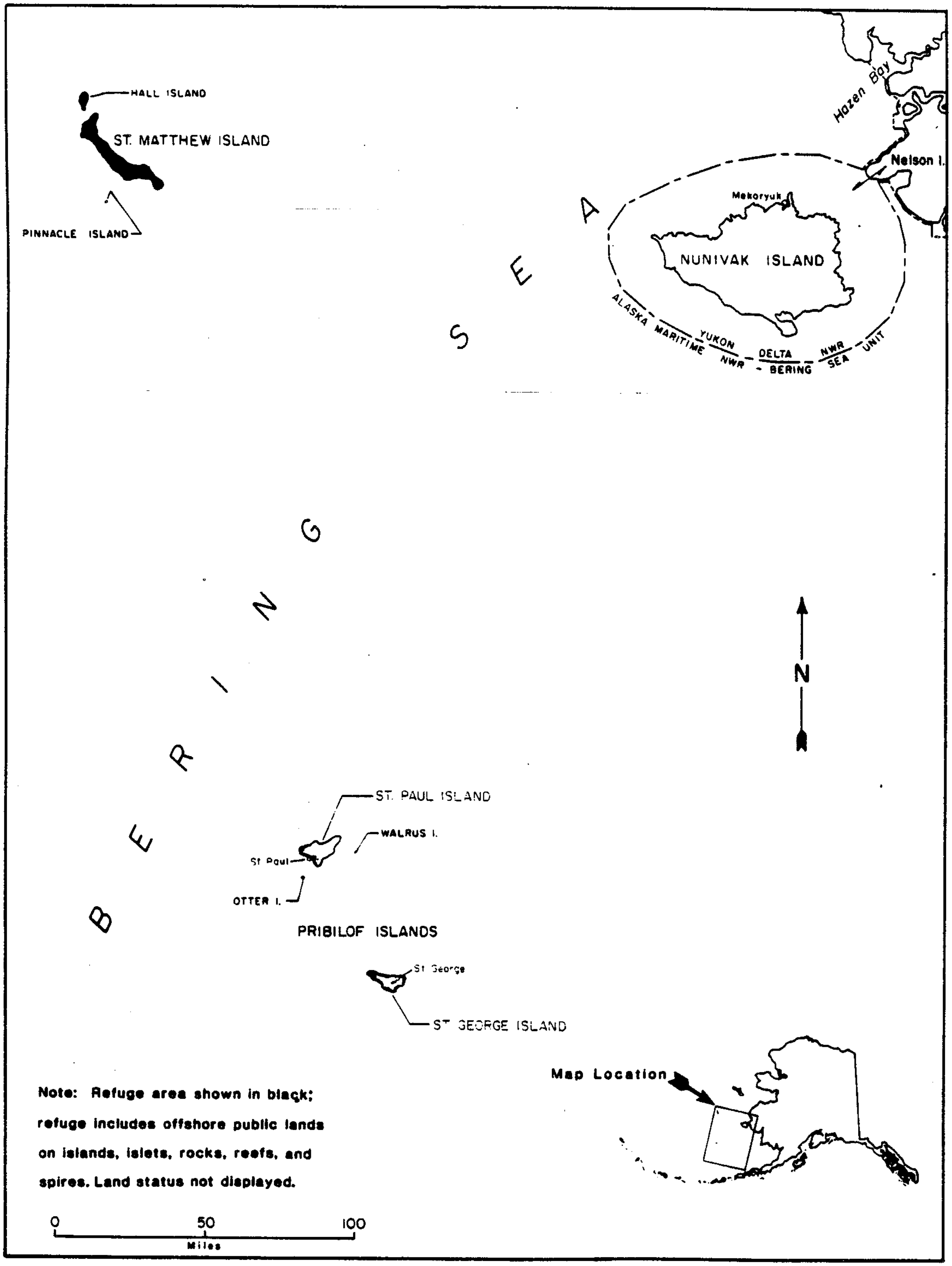


Figure 5. Location map of the Bering Sea Unit, map 3 of 3.

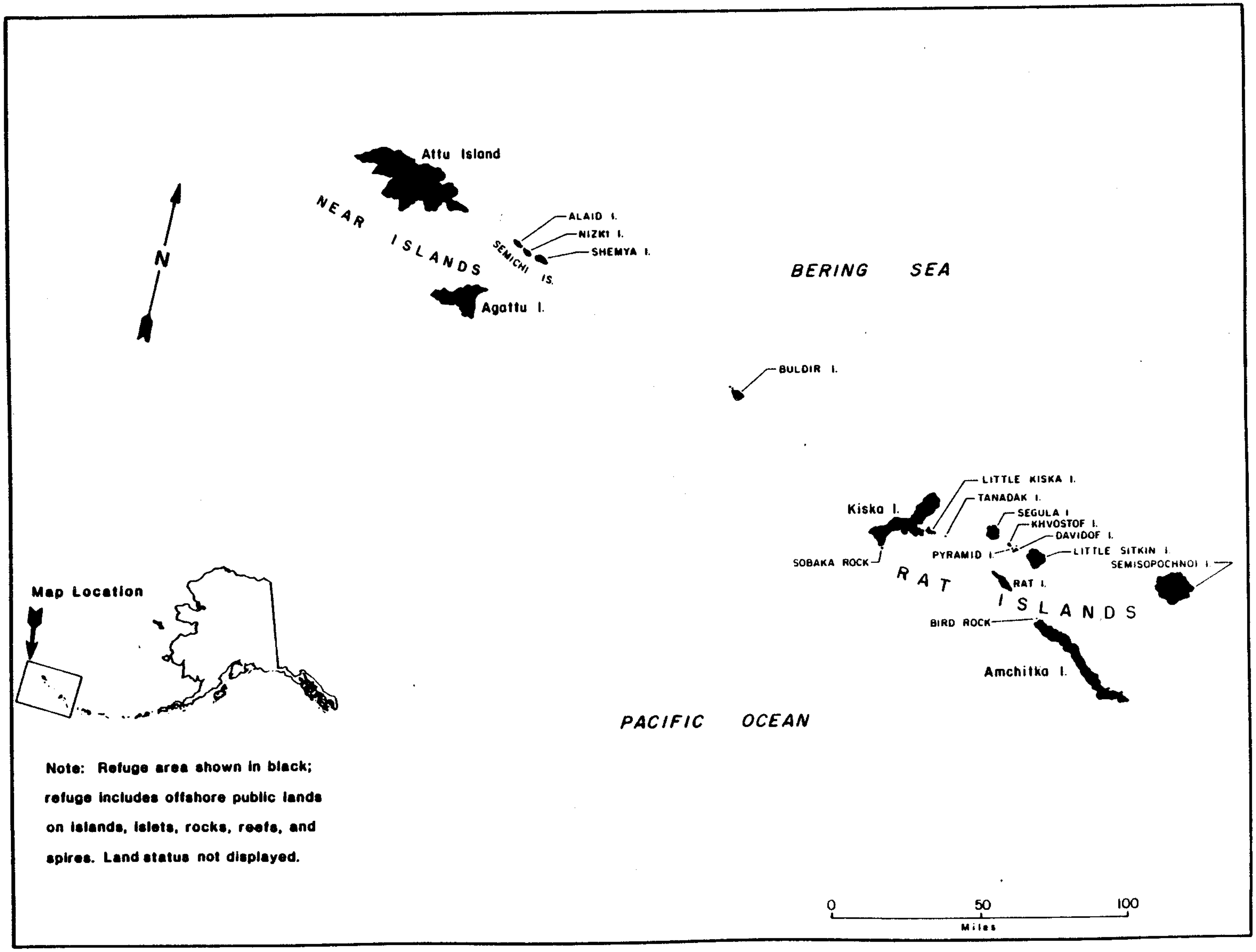


Figure 6. Location map of the Aleutian Islands Unit, map 1 of 3.

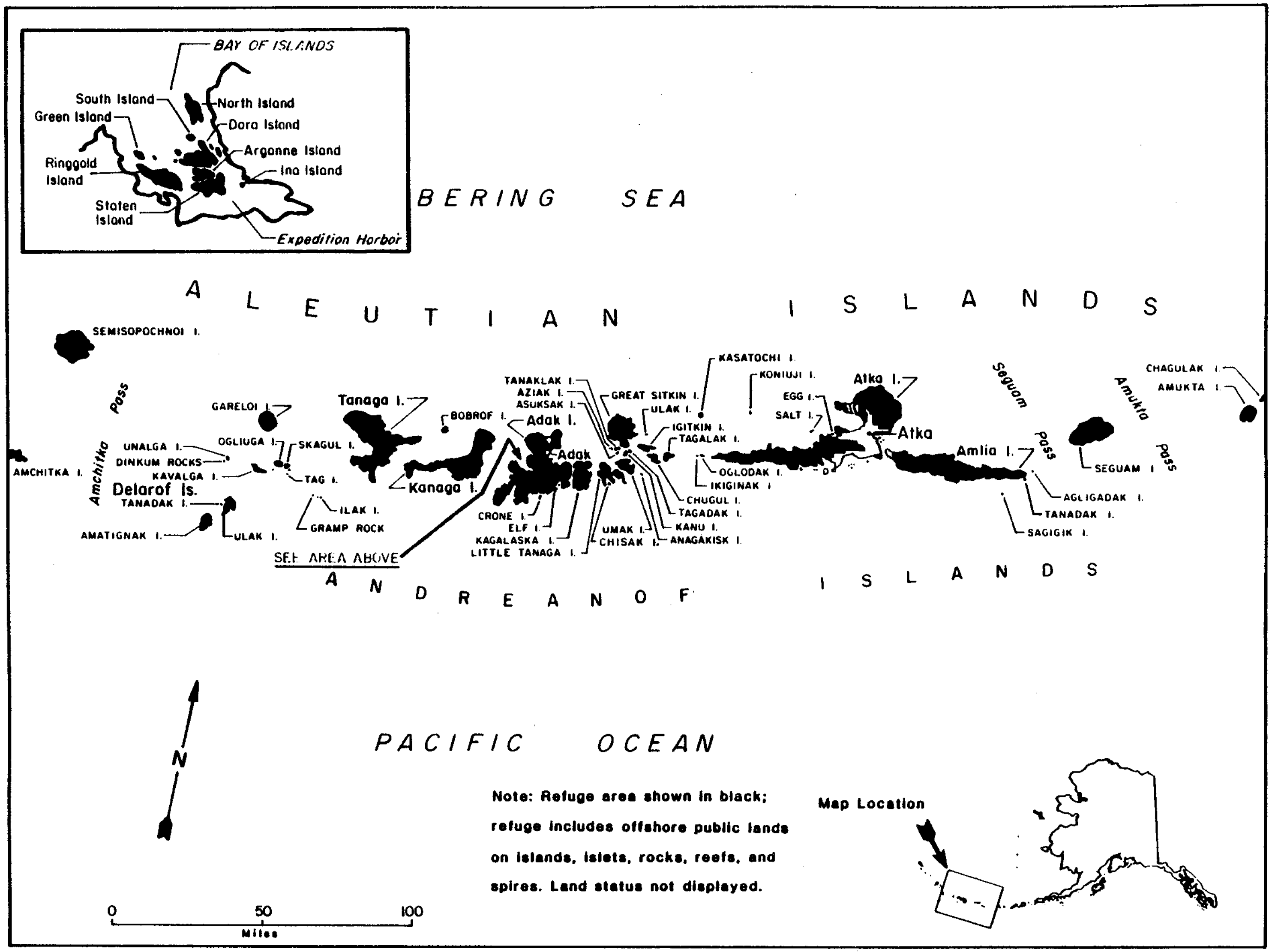


Figure 7. Location map of the Aleutian Islands Unit, map 2 of 3.

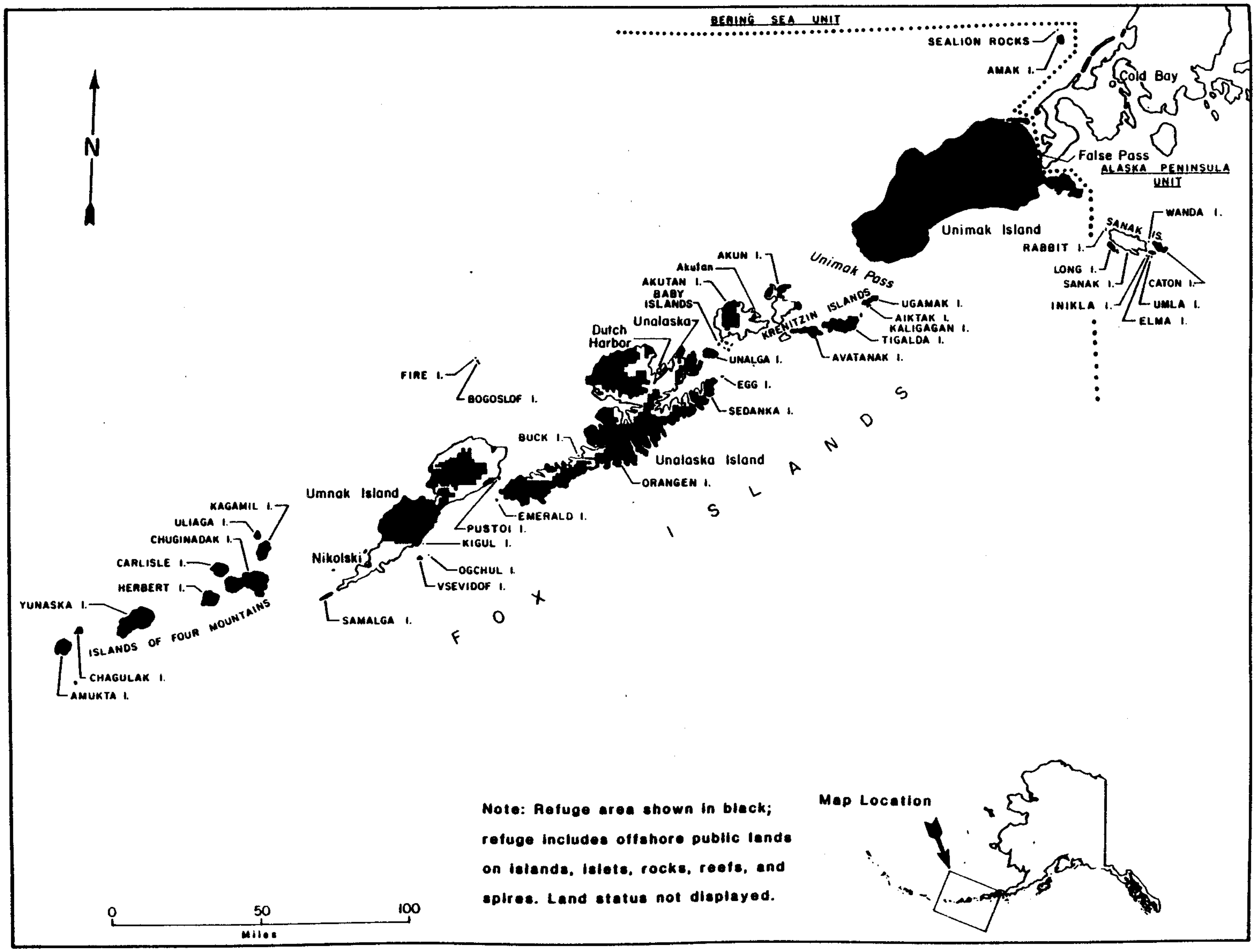


Figure 8. Location map of the Aleutian Islands Unit, map 3 of 3.

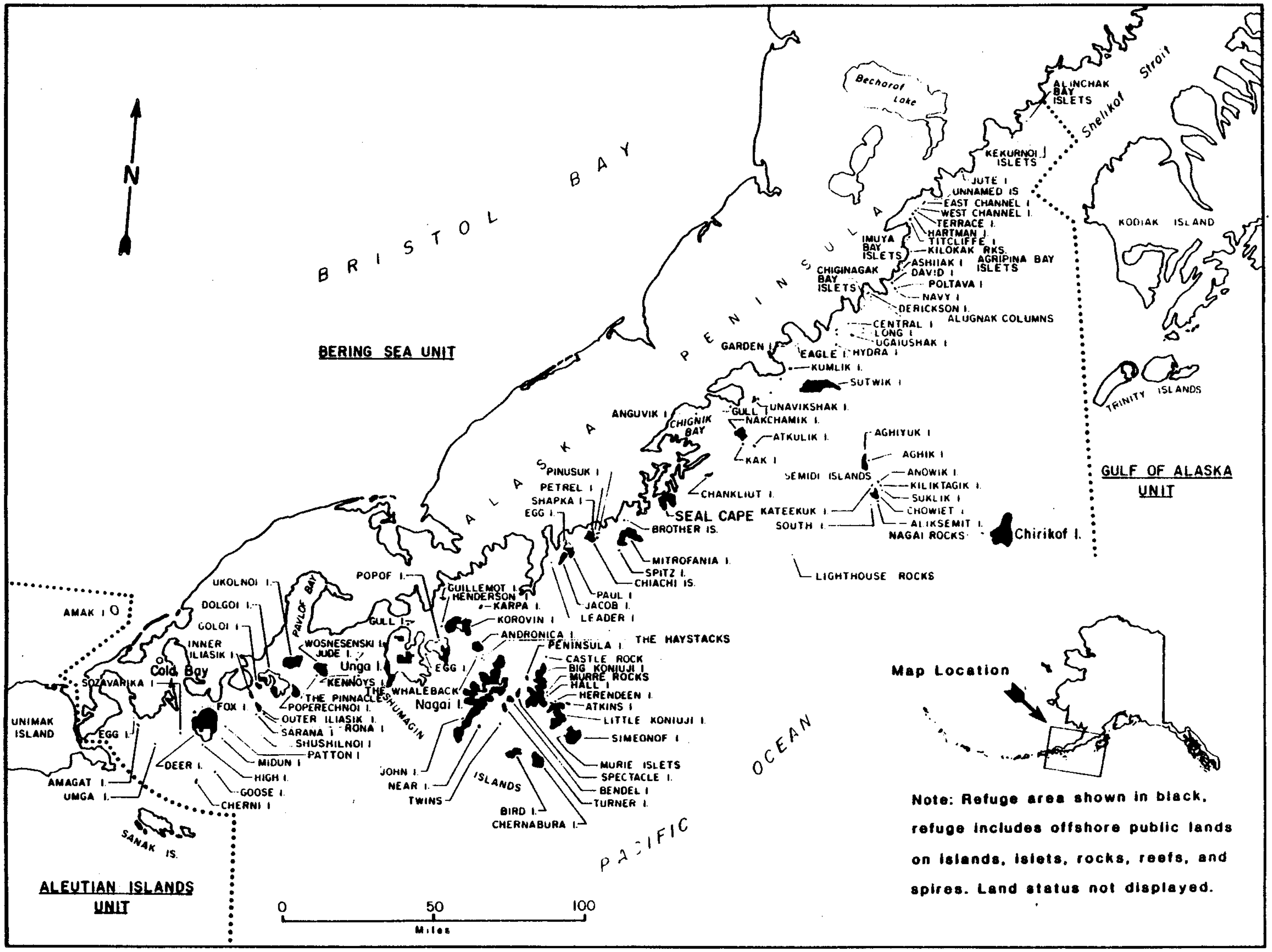


Figure 9. Location map of the Alaska Peninsula Unit.

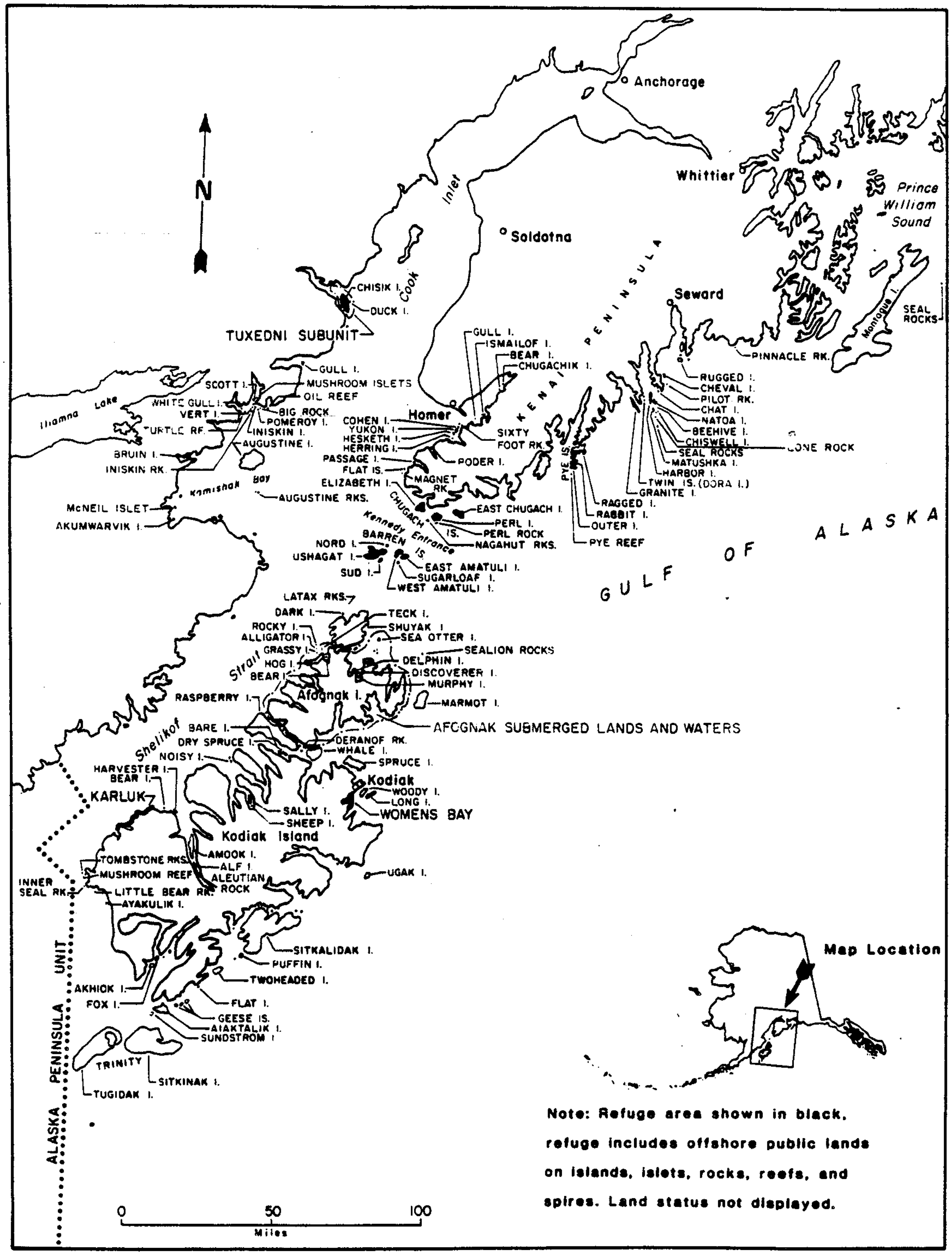


Figure 10. Location map of the Gulf of Alaska Unit, map 1 of 3.

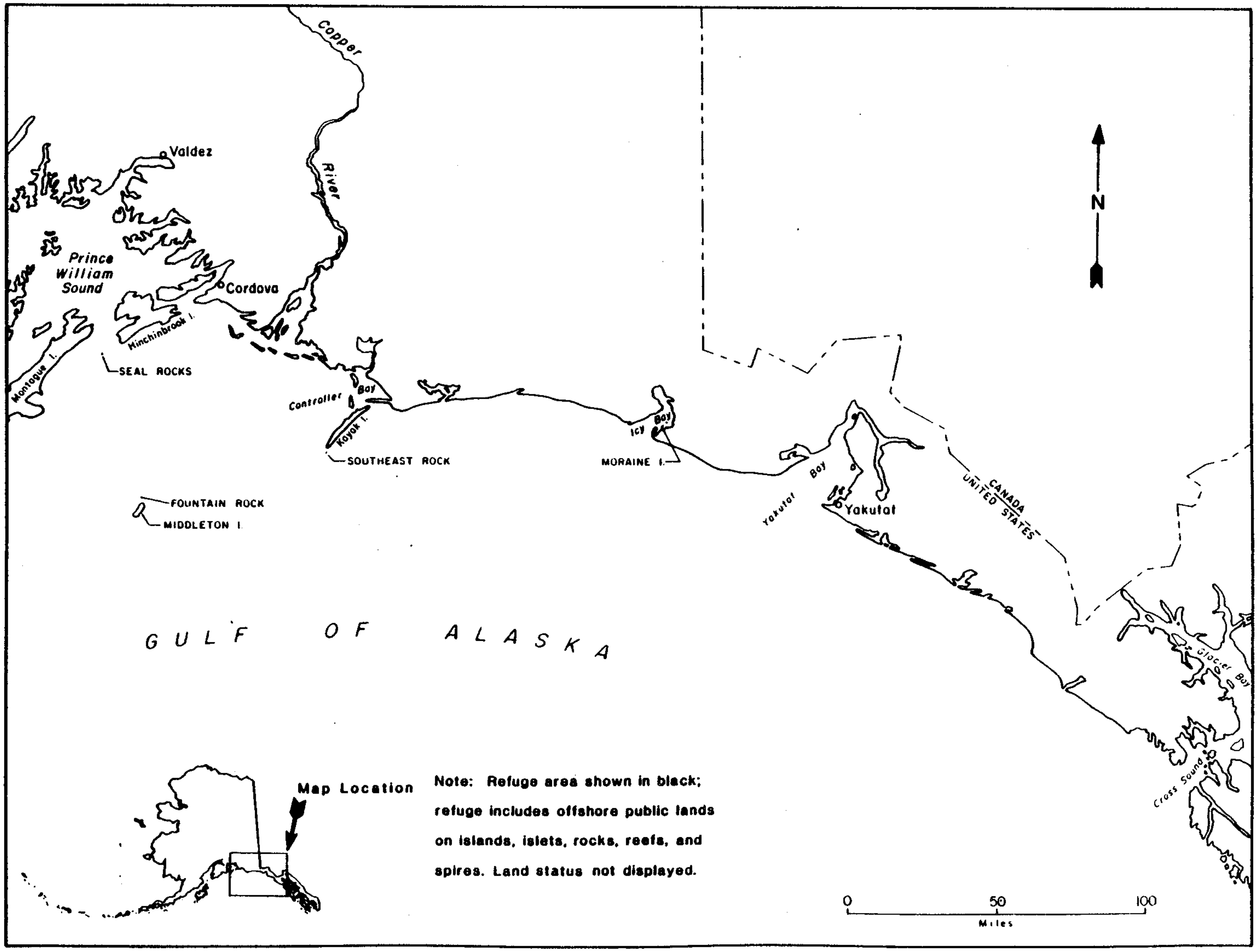


Figure 11. Location map of the Gulf of Alaska Unit, map 2 of 3.

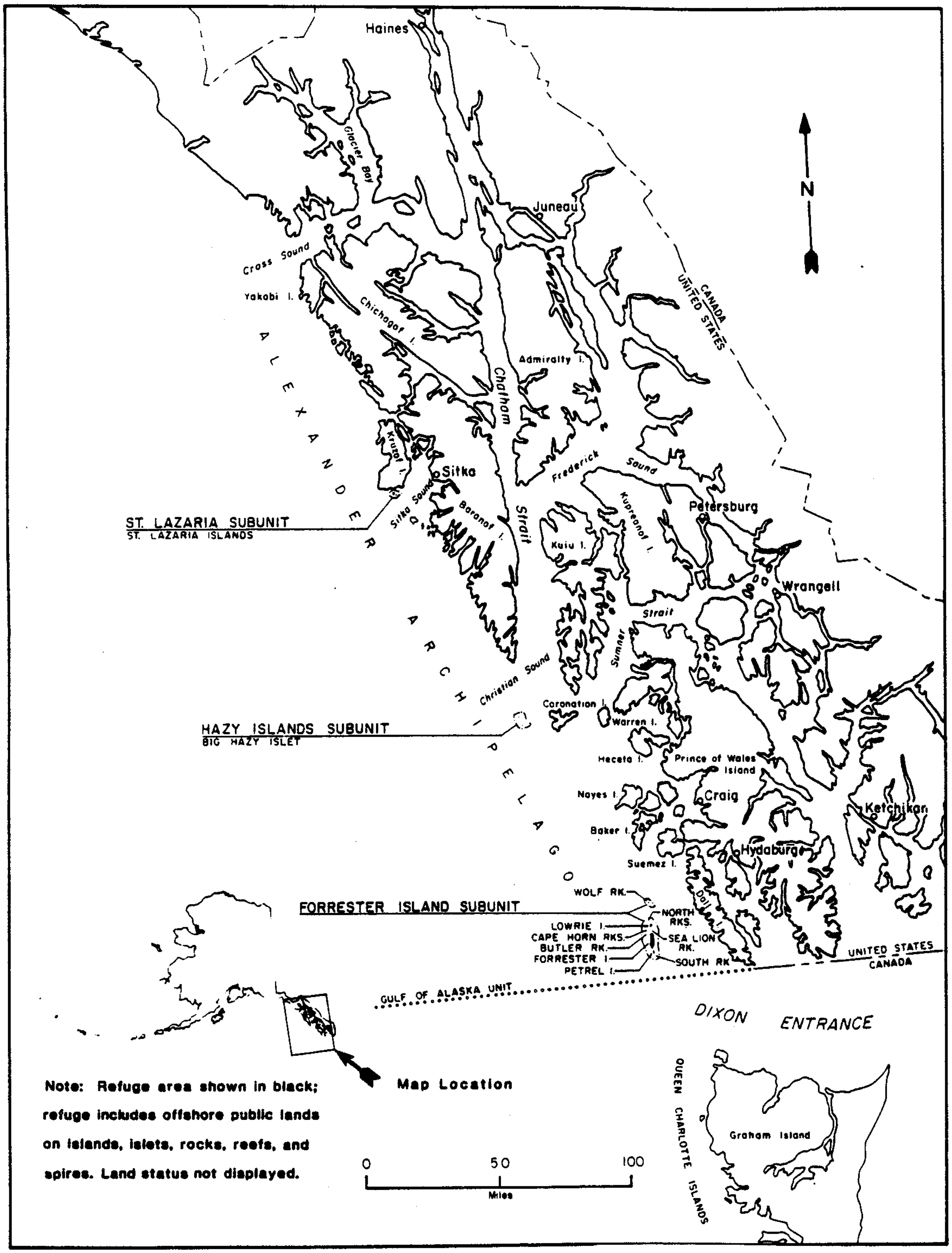


Figure 12. Location map of the Gulf of Alaska Unit, map 3 of 3.

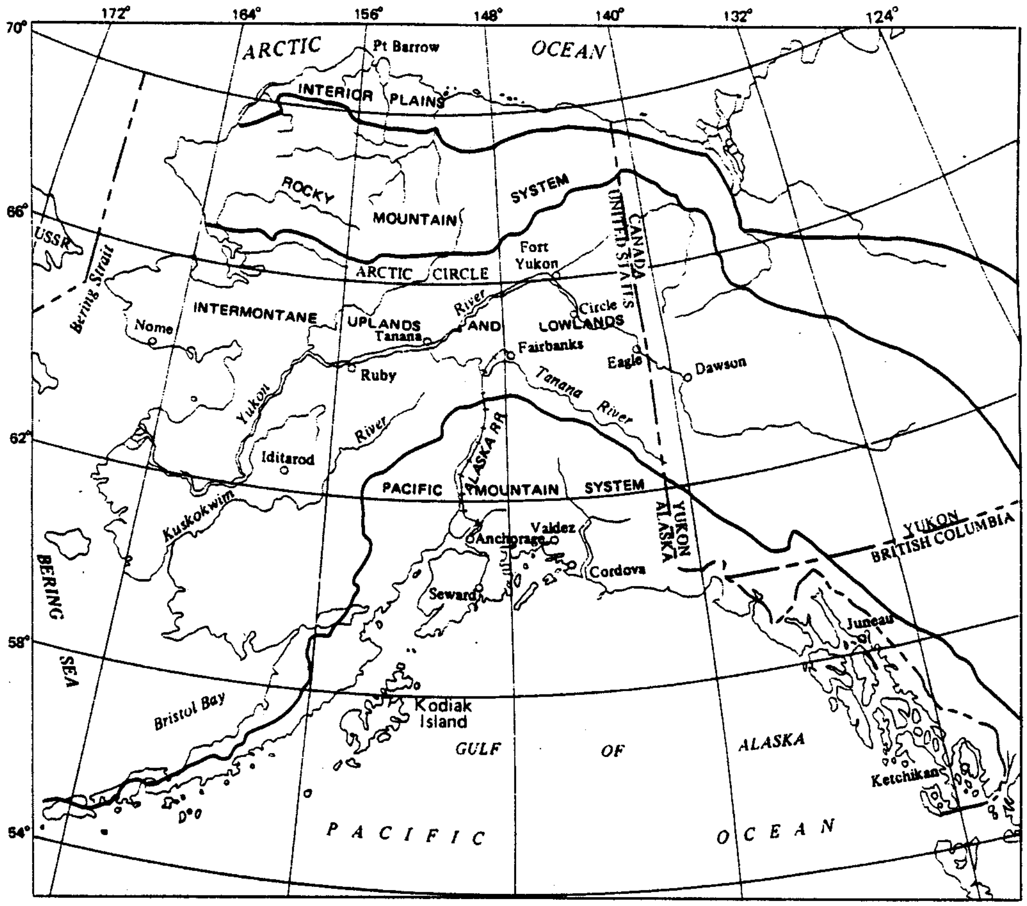


Figure 13. Map showing the major physiographic divisions within Alaska (from Wahrhaftig, 1965).

The Chukchi Sea Unit lies within the Interior Plains, the Rocky Mountain System, and the Intermontane Plateaus physiographic divisions. This unit lies within the Arctic Coastal Plain province of the Interior Plains division; the Arctic Foothills and Arctic Mountains provinces of the Rocky Mountain System; and the Western Alaska and Seward Peninsula provinces of the Intermontaine Plateaus division.

The Bering Sea Unit lies within the Ahklun Mountains, Bering Shelf, Seward Peninsula, and Western Alaska provinces of the Intermontaine Plateaus physiographic division.

The Aleutian Islands Unit lies almost totally within the Alaska-Aleutian province of the Pacific Mountain System. The northeastern coast of Unimak Island, between Rocky Point and Urilia Bay, is in the Western Alaska province of the Intermontane Plateaus division.

The Alaska Peninsula Unit lies entirely within the Alaska-Aleutian province of the Pacific Mountain System.

The Gulf of Alaska Unit lies within the Alaska-Aleutian, Coastal Trough, and Pacific Border Ranges provinces of the Pacific Mountain System.

Stratigraphy

This section of the report will discuss the rocks along the entire coastline within each unit of the refuge, rather than just that of the headlands, islands, etc. within the refuge. This section is taken from Beikman (1980).

Chukchi Sea Unit

Sedimentary and metasedimentary rocks

Precambrian (more than 570 million years old - Ma)

Siltstone, phyllite, graywacke, quartz schist, graphitic schist, tactite, and schistose, argillaceous, dolomitic limestone.

Paleozoic (570 Ma to 245 Ma)

Limestone, dolomite, argillite, chert, graywacke, schists, quartzite, slate, greenstone, marble, phyllite, shale, sandstone, and conglomerate.

Jurassic and Triassic (245 Ma to 144 Ma)

Shale, siltstone, chert, graywacke, limestone, and sandstone.

Cretaceous and Jurassic (208 Ma to 66.4 Ma)

Argillite, shale, graywacke, quartzite, conglomerate, tuff, and agglomerate.

Lower Cretaceous (144 Ma to 97.5 Ma)

Graywacke, sandstone, shale, siltstone, conglomerate, coaly shale, coal, ironstone, and bentonite.

Upper Cretaceous (97.5 Ma to 66.4 Ma)

Sandstone, conglomerate, shale, and siltstone.

Tertiary (66.4 Ma to 1.6 Ma)

Sandstone, siltstone, and shale.

Quaternary (younger than 1.6 Ma)

Alluvial, glacial, lacustrian, eolian, beach, and volcanic sediments.

Igneous and metamorphosed igneous rocks

Jurassic, Triassic, and Permian (286 Ma to 144 Ma)

Basaltic volcanic rocks

Lower Cretaceous (144 Ma to 97.5 Ma)

Trachytic to andesitic volcanic rocks

Quaternary and Tertiary (younger than 66.4 Ma)

Basaltic volcanic rocks

Bering Sea Unit

Sedimentary and metasedimentary rocks

Precambrian (older than 570 Ma)

Siltstone, phyllite, graywacke, quartz schist, graphitic schist, tactite, gneiss, slate and schistose, argillaceous, dolomitic limestone.

Paleozoic (570 Ma to 245 Ma)

Limestone, dolomite, marble, chert, shale, and sandstone.

Jurassic (208 Ma to 144 Ma)

Sandstone, siltstone, shale, conglomerate, argillite, and graywacke.

Cretaceous and Jurassic (208 Ma to 66.4 Ma)

Argillite, shale, graywacke, quartzite, conglomerate, tuff, and agglomerate.

Cretaceous (144 Ma to 66.4 Ma)

Graywacke, sandstone, shale, siltstone, and conglomerate.

Tertiary (66.4 Ma to 1.6 Ma)

Sandstone, siltstone, conglomerate, argillite, graywacke, volcanic breccia, shale, claystone, and coal.

Quaternary (younger than 1.6 Ma)

Alluvial, glacial, lacustrian, eolian, beach, and volcanic sediments.

Igneous and metamorphic rocks

Unknown age

Ultramafic rocks.

Precambrian (older than 570 Ma)

Undifferentiated volcanic rocks.

Precambrian and/or Paleozoic (older than 245 Ma)

Undifferentiated intrusive rocks.

Permian (286 Ma to 245 Ma)

Gabbroic intrusive rocks.

Cretaceous (144 Ma to 66.4 Ma)

Granitic to dioritic and possibly gabbroic intrusive rocks and trachytic to andesitic, and possibly rhyolitic to basaltic volcanic rocks.

Tertiary (66.4 Ma to 1.6 Ma)

Undifferentiated intrusive and volcanic rocks.

Quaternary (younger than 1.6 Ma)

Basaltic and possibly rhyolytic to basaltic volcanic rocks.

Aleutian Islands Unit

Sedimentary and metasedimentary rocks

Tertiary (66.4 Ma to 1.6 Ma)

Sandstone, siltstone, and shale of volcanic origin interbedded with mafic flows, dikes, and sills, and conglomerate, argillite, and graywacke.

Quaternary (younger than 1.6 Ma)

Alluvial, glacial, lacustrian, eolian, beach, and volcanic sediments.

Igneous and metamorphosed igneous rocks

Tertiary (66.4 Ma to 1.6 Ma)

Trachytic to basaltic and some undifferentiated volcanic rocks and granitic through gabbroic intrusive rocks.

Quaternary (younger than 1.6 Ma)

Rhyolitic to basaltic volcanic rocks

Alaska Peninsula Unit

Sedimentary and metasedimentary rocks

Triassic (245 Ma to 208 Ma)

Limestone, shale, and chert.

Jurassic (208 Ma to 144 Ma)

Sandstone, siltstone, shale, conglomerate, and argillite.

Jurassic to Cretaceous (208 Ma to 66.4 Ma)

Marine sandstone, arkose, siltstone, and limestone.

Cretaceous (144 Ma to 66.4 Ma)

Nonmarine and marine clastic rocks, siltstone, and shale.

Tertiary (66.4 Ma to 1.6 Ma)

Sandstone, siltstone, conglomerate, volcanic breccia, and shale.

Quaternary (younger than 1.6 Ma)

Alluvial, glacial, lacustrian, eolian, beach, and volcanic sediments.

Igneous and metamorphosed igneous rocks

Tertiary (66.4 Ma to 1.6 Ma)

Undifferentiated volcanic and granitic to dioritic intrusive rocks.

Quaternary (younger than 1.6 Ma)

Undifferentiated volcanic rocks.

Gulf of Alaska Unit

Sedimentary and metasedimentary rocks

Precambrian and/or Paleozoic (older than 245 Ma)

Volcanic greenschist and marble.

Ordovician (505 Ma to 438 Ma)

Argillite, chert, and limestone.

Ordovician and Silurian (505 Ma to 408 Ma)

Graywacke, conglomerate, shale, siltstone, tuff, and limestone.

Silurian (438 Ma to 408 Ma)

Graywacke, shale, siltstone, limestone, sandstone, argillite, mudstone, and conglomerate.

Silurian and Devonian (438 Ma to 360 Ma)

Limestone, dolomite, marble, and shale.

Devonian (408 Ma to 360 Ma)

Limestone, phyllite, schist, marble, shale, graywacke, conglomerate, and amphibolite.

Triassic (245 Ma to 208 Ma)

Limestone, shale, chert, tuff, tuffaceous conglomerate and breccia, pillow basalts, graywacke, argillite, sandstone, and greenstone.

Jurassic and Cretaceous (208 Ma to 66.4 Ma)

Graywacke, slate, argillite, conglomerate, volcaniclastic sediments, sandstone, siltstone, limestone, greenstone, chert, and greenschist.

Cretaceous (144 Ma to 66.4 Ma)

Sandstone, siltstone, shale, and limestone.

Tertiary (66.4 Ma to 1.6 Ma)

Conglomerate, sandstone, volcanic breccia, shale, siltstone, argillite, graywacke, carbonaceous shale, mudstone, claystone, and coal.

Quaternary (younger than 1.6 Ma)

Alluvial, glacial, lacustrian, eolian, beach, and volcanic sediments.

Igneous and metamorphosed igneous rocks

Unknown age

Ultramafic rocks.

Jurassic (208 Ma to 144 Ma)

Syenitic to gabbroic intrusive rocks.

Jurassic to Cretaceous (208 Ma to 66.4 Ma)

Basaltic volcanic and syenitic to dioritic intrusive rocks.

Cretaceous to Tertiary (144 Ma to 1.2 Ma)

Granitic to dioritic intrusive rocks.

Tertiary (66.4 Ma to 1.6 Ma)

Basaltic volcanic and granitic to dioritic intrusive rocks.

Tertiary to Quaternary (younger than 66.4 Ma)

Undifferentiated volcanic rocks.

Quaternary (younger than 1.6 Ma)

Undifferentiated volcanic rocks.

Tectonics

Alaska has numerous tectonostratigraphic terranes which make for an extremely complex tectonic history. Jones et al., (1983) define tectonostratigraphic terranes as "fault-bounded geologic entities of regional extent, each characterized by a geologic history that is different from the histories of contiguous terranes." Earth scientists generally understand that tectonostratigraphic terranes were often formed in locations other than that in which they now occur. Jones et al., (1987) and Monger and Berg (1987) recognize fifty-five terranes in Alaska. The Alaska Maritime NWR does not contain all of these terranes, as many of them are located in the interior. The following discussion of the terranes present in each unit of the refuge was compiled from Jones et al.,(1987) and Monger and Berg (1987).

Chukchi Sea Unit

Large areas of the Chukchi Sea Unit are covered by Upper Cretaceous (97.5 Ma to 66.4 Ma) and Tertiary or Quaternary (younger than 66.4 Ma) sediments and/or volcanic rocks. These prevent determination of the underlying terrane(s).

Arctic Alaska terrane

DeLong Mountains subterrane - Complex stratigraphic assemblage characterized by thick Devonian and Mississippian (408 Ma to 320 Ma) carbonates and younger sequences of chert and argillite.

Endicott Mountains subterrane - Stratified sequence of Devonian (408 Ma to 360 Ma) clastic rocks, Mississippian (360 Ma to 320 Ma) shale and carbonate rocks, and younger Paleozoic and lower Mesozoic (320 Ma to 208? Ma) chert, argillite, and calcareous rocks.

Hammond subterrane - Structurally complex and polymetamorphosed assemblage of middle Paleozoic and older (older than 360? Ma) carbonate rocks, calc-schist, quartz-mica schist, quartzite, and metarhyolite; intruded by Late Devonian (374 Ma to 360 Ma) gneissic granitic rocks. Precambrian (older than 570 Ma) basement rocks may be present locally.

North Slope subterrane - Precambrian to lower Paleozoic (older than 438? Ma) basement rocks overlain by Kekiktuk Conglomerate (Mississippian - 360 Ma to 320 Ma), Lisburne Group (Mississippian and Pennsylvanian - 360 Ma to 286 Ma), Sadlerochit Group (Permian and Triassic - 286 Ma to 208 Ma), and younger Mesozoic (208 Ma to 66.4 Ma) strata.

Angayucham terrane - Structurally and stratigraphically complex assemblege of oceanic rocks, including gabbro, diabase, pillow basalt, tuff, chert, graywacke, argillite, and minor limestone; sedimentary rocks range in age from Mississippian to Jurassic (360 Ma to 144 Ma). Major periods of basaltic volcanism appear to be late Carboniferous (320 Ma to 286 Ma) and Late Triassic (230 Ma to 208 Ma), although many volcanic sequences are not well dated. Separate thrust sheets of plutonic ultramafic rocks are found throughout the terrane, but none of these can yet be genetically linked to the basaltic rocks. The Angayucham terrane structurally overlies the Ruby terrane to the south and the Arctic Alaska terrane to the north.

Koyukuk terrane - Andesitic flows, tuffs, breccias, agglomerates, conglomerates, tuffaceous graywacke, and mudstone; local intercalations of shelly limestone contain Early Cretaceous (144 Ma to 97.5 Ma) fossils.

Seward terrane - Regionally metamorphosed, structurally complex assemblage of mica schist, micaceous calc-schist, metavolcanics (some containing glaucophane), marble, and high-grade gneissic rocks. Rocks of probable Precambrian (older than 570 Ma) and known Devonian (408 Ma to 360 Ma) age are present but protolithic and metamorphic ages of most rocks are uncertain.

Bering Sea Unit

Large areas of the Bering Sea Unit are covered by Upper Cretaceous (97.5 Ma to 66.4 Ma) and Tertiary or Quaternary sediments (younger than 66.4 Ma) and/or volcanic rocks. These prevent determination of the underlying terrane(s).

Arctic Alaska terrane

DeLong Mountains subterrane - Complex stratigraphic assemblege characterized by thick Devonian and Mississippian (408 Ma to 320 Ma) carbonates and younger sequences of chert and argillite.

Kilbuck terrane - Gneiss and schist exposed in the Kanektok River region, including biotite-hornblende gneiss, garnet amphibolite, quartz-mica schist, and marble. Metamorphism occurred during the Precambrian (more than 570 Ma).

Peninsular terrane - Permian (286 Ma to 245 Ma) limestone; Upper Triassic (230 Ma to 208 Ma) limestone, argillite, basalt, and tuff; Lower Jurassic (208 Ma to 187 Ma) andesitic flows, breccias, and volcaniclastic siltstone and sandstone; Middle Jurassic to Cretaceous (187 Ma to 66.4 Ma) fossiliferous clastic rocks and minor bioclastic limestone; and Jurassic (208 Ma to 144 Ma) batholithic granitic rocks.

Seward terrane - Regionally metamorphosed, structurally complex assemblage of mica schist, micaceous calc-schist, metavolcanics (some containing glaucophane), marble, and high-grade gneissic rocks. Rocks of probable Precambrian (older than 570 Ma) and known Devonian (408 Ma to 360 Ma) age are present, but protolithic and metamorphic ages of most rocks are uncertain.

Togiak terrane - Structurally complex, thick assemblage of Jurassic and Lower Cretaceous (208 Ma to 97.5 Ma) volcanic and volcaniclastic rocks, including pillowed flows, tuffs, breccias, conglomerate, graywacke, chert, and minor shelly argillaceous limestone of Early Cretaceous (144 Ma to 97.5 Ma) age.

York terrane - Weakly metamorphosed, structurally complex assemblage of Precambrian(?) to lower Paleozoic (younger than 360? Ma) fine-grained clastic rocks, argillaceous limestone, and fossiliferous limestone of Ordovician and Silurian (505 Ma to 408 Ma) ages. Younger strata are estimated to be as much as 3,000 meters thick and may include rocks of late Precambrian (2,500 Ma to 570 Ma), Cambrian (570 Ma to 505 Ma), and Devonian (408 Ma to 360 Ma) ages.

Aleutian Islands Unit

The Aleutian Islands Unit is composed almost entirely of Tertiary and Quaternary (younger than 66.4 Ma) volcanic and volcaniclastic rocks. That portion of Unimak Island that is possibly not of volcanic origin is covered by Quaternary (younger than 1.6 Ma) sediments which makes it impossible to determine which, if any, terrane underlies that area.

Alaska Peninsula Unit

Tertiary and Quaternary (younger than 66.4 Ma) sediments and/or volcanic rock cover portionsl of the Alaskan Peninsula unit. These prevent determination of the underlying terrane(s).

Peninsular terrane - Permian (286 Ma to 245 Ma) limestone; Upper Triassic (230 Ma to 208 Ma) limestone, argillite, basalt, and tuff; Lower Jurassic (208 Ma to 187 Ma) andesitic flows, breccias, and volcaniclastic siltstone and sandstone; Middle Jurassic to Cretaceous (187 Ma to 66.4 Ma) fossiliferous clastic rocks and minor bioclastic limestone; and Jurassic (208 Ma to 144 Ma) batholithic granitic rocks.

Gulf of Alaska Unit

Tertiary and Quaternary (younger than 66.4 Ma) sediments and/or volcanic rock cover portions of the Gulf of Alaska unit. These prevent determination of the underlying terrane(s).

Alexander terrane

Craig subterrane - Pre-Ordovician (older than 505 Ma) metamorphic complex and Ordovician to Triassic (505 Ma to 208 Ma) mafic to felsic volcanic rocks and terriginous clastic and carbonate rocks.

Chugach terrane - Complexly folded and weakly metamorphosed Upper Cretaceous (97.5 Ma to 66.4 Ma) graywacke and slate, locally interleaved with disrupted assemblages of Jurassic and Cretaceous (208 Ma to 66.4 Ma) radiolarian chert, gabbro, ultramafic rocks, pillow basalt, and tuff, as well as rare blocks, of limestone, diorite, and other exotic lithologic types.

Ghost Rocks terrane - Strongly deformed and locally chaotically jumbled, assemblage of pillow lava, pillow breccia, and tuff of andesitic to basaltic va of Paleocene (66.4 Ma to 57.8 Ma) age; intruded by sparse plutons of quartz diorite to tonalite composition with ages of about 62 Ma.

Kachemak terrane - Small sliver of pillow basalt, chert, and minor limestone structurally wedged between the Peninsular terrane and the Chugach terrane. Radiolarian cherts are Triassic (245 Ma to 208 Ma) in age.

Peninsular terrane - Permian (286 Ma to 245 Ma) limestone; Upper Triassic (230 Ma to 208 Ma) limestone, argillite, basalt, and tuff; Lower Jurassic (208 Ma to 187 Ma) andesitic flows, breccias, and volcaniclastic siltstone and sandstone; Middle Jurassic to Cretaceous (187 Ma to 66.4 Ma) fossiliferous clastic rocks and minor bioclastic limestone; and Jurassic (208 Ma to 144 Ma) batholithic granitic rocks.

Prince William terrane - Strongly deformed thick assemblage of graywacke, argillite, minor conglomerate, pillow basalt, basaltic tuff, sills, and dikes. Contains rare fossils of Paleocene and Eocene (66.4 Ma to 36.6 Ma) age and is intruded by plutons of gabbro, tonalite, and granodiorite of early middle Eocene (52 Ma to 43.6 Ma) age.

Wrangellia terrane - Stratigraphic assemblage of basal upper Paleozoic (360? Ma to 245 Ma) arc-related, volcanic breccias, flows, and volcaniclastic rocks, overlain by nonvolcanic Permian (286 Ma to 245 Ma) limestone, pelitic rocks, and chert. Triassic (245 Ma to 208 Ma) rocks commence with blank cherty argillite, overlain by thousands of meters of subaerial to pillowed basalt. Above this are platformal and basinal Upper Triassic (230 Ma to 208 Ma) limestones that grade upward into basinal, spiculitic, argillaceous and calcareous rocks. Succeeding Jurassic and Cretaceous (208 Ma to 66.4 Ma) rocks are predominantly clastic.

Yakutat terrane - Upper Mesozoic (144? Ma to 66.4 Ma) graywacke and shale, containing structurally interleaved lenses of disrupted chert, argillite, and volcanic rocks. Includes a basalt and a shale rich in organic matter, both of Eocene (57.8 Ma to 36.6 Ma) age.

DESCRIPTION OF KNOWN OIL AND GAS RESOURCES

Arctic North Slope

There are fourteen known oil or oil and gas fields and nine known gas fields on the Arctic North Slope of Alaska. Prudhoe Bay, Kuparuk River, Lisburne, and Endicott fields are the only producing oil fields on the North Slope (February, 1988). Umiat, East Barrow, Simpson, Fish Creek, Colville Delta, Milne Point, Gwydyr Bay, Point Thomson, West Sak, and Ugnu fields are either too small to be economic, currently shut-in, or not fully explored.

Kavik, Kemik, Gubik, East Umiat, Wolf Creek, Square Lake, Meade, and Walakpa gas fields are not being produced and are not now, and may never be, economic. Barrow gas field provides gas for local consumption in the town of Barrow.

Cook Inlet Basin

There are seven oil or oil and gas fields in the Cook Inlet Basin. Beaver Creek, Granite Point, McArthur River, Middle Ground Shoal, Swanson River, and Trading Bay fields produce oil, Beaver Creek, McArthur River, Middle Ground Shoal, and Trading Bay also produce gas. Redoubt Shoal field has been shut-in since discovery.

There are seventeen gas fields in the Cook Inlet Basin. Cannery Loop, Kenai, North Cook Inlet, Beluga River, and Lewis River are gas fields that are in production. Birch Hill, Falls Creek, West Fork, North Middle Ground Shoal, Ivan River, Moquawkie, Nicolai Creek, Stump Lake, West Foreland, Albert Kaloa, North Fork, and Theodore River gas fields are not in production.

Gulf of Alaska Tertiary Province

The first successful oil well in Alaska was drilled near Katalla in 1902. The Katalla field produced about 150,000 barrels of oil before abandonment during the early 1930s (Cobb, 1973).

POTENTIAL FOR OIL AND GAS OCCURRENCE

The classification system for the potential of oil and gas occurrence is based on BLM's mineral potential classification system (Appendix B). This system consists of two parts, an occurrence potential and a level of confidence, expressed as L1/L2, where L1 is a letter representing the occurrence potential and L2 is a letter representing the level of confidence. "O", "L", "M", and "H" are the letters representing occurrence potentials of NO, LOW, MODERATE, and HIGH, respectively, while "A", "B", "C", and "D" are the letters representing increasing levels of confidence, with "A" indicating the least confidence and "D" representing the most confidence.

The discussion of the oil and gas (hydrocarbon) occurrence potential of the Alaska Maritime NWR is broken into smaller geographically and/or geologically related areas. The discussion of each area's geology and geochemistry is referenced to another refuge's oil and gas assessment or actually discussed with enough detail to explain the occurrence potential of the area.

Chukchi Sea Unit

Northern Chukchi Sea Unit Boundary to Omalik Lagoon

Alaska Maritime NWR between the northern Chukchi Sea Unit boundary and Omalik Lagoon is part of the Arctic Coastal Plain. All of the refuge north of Icy Cape is immediately adjacent to the National Petroleum Reserve in Alaska (NPRA). This area includes the Seahorse Islands, Point Franklin, islets in west Peard Bay, and Icy Cape.

Geology

The geology of this area is the same as that of western NPRA.

Stratigraphy -- Sedimentary Rocks

The rocks of this area of Alaska Maritime NWR are divided into three major sequences: the Franklinian, the Ellesmerian, and the Brookian. The rocks of the Franklinian sequence are the oldest, greater than 408 million years old (Ma); and the rocks of the Brookian sequence are the youngest, less than 119 Ma. Figures 14 and 15 show the generalized stratigraphy of this area.

Franklinian Sequence - Pre-Devonian

Pre-Devonian, complexly deformed, low- to medium-rank metamorphosed sedimentary rocks, such as slate and quartzite with minor amounts of anthracite coal comprise the Franklinian sequence rocks. Abundant calcite and quartz fracture fillings occur in some localities.

The Katakturok Formation, the Nanook Formation, and the Neruokpuk Formation form the Franklinian sequence.

Ellesmerian Sequence

The Ellesmerian sequence rocks range in age from 380 Ma to about 119 Ma. They include a variety of marine to fluvial sediments derived from a northerly source.

Upper Devonian to Lower Mississippian

Up to 1,000 feet of Endicott Group sandstone, conglomerate, shale, and minor limestone and coal unconformably overlie the Franklinian sequence rocks. The Endicott Group rocks range in age from 380 Ma to 333 Ma. All clastic rocks under the overlying Lisburne carbonates are generally assumed to be within the Endicott Group.

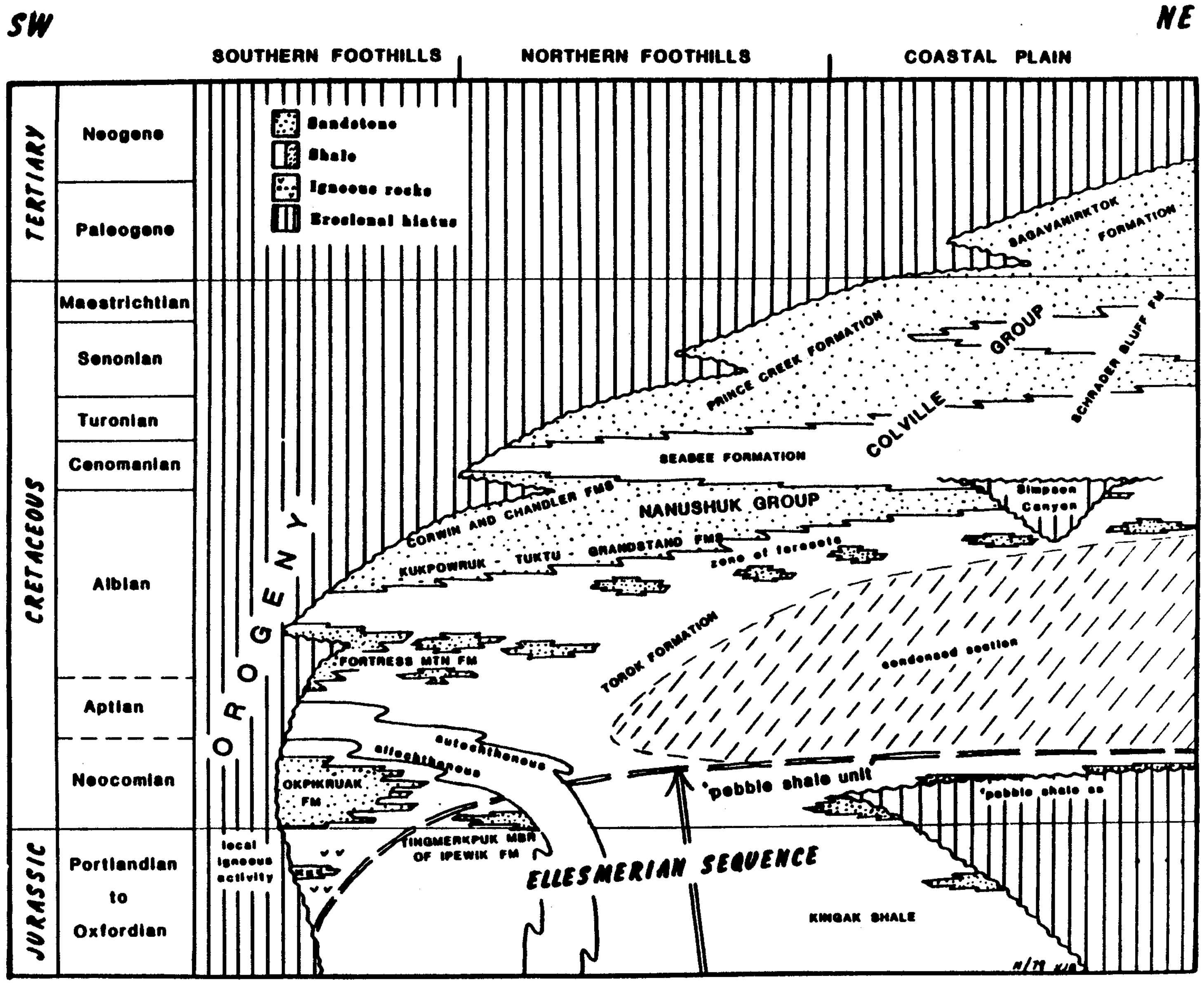


Figure 14. Time-stratigraphic diagram of the Brookian sequence of the North Slope in Alaska (from Bird, 1981).

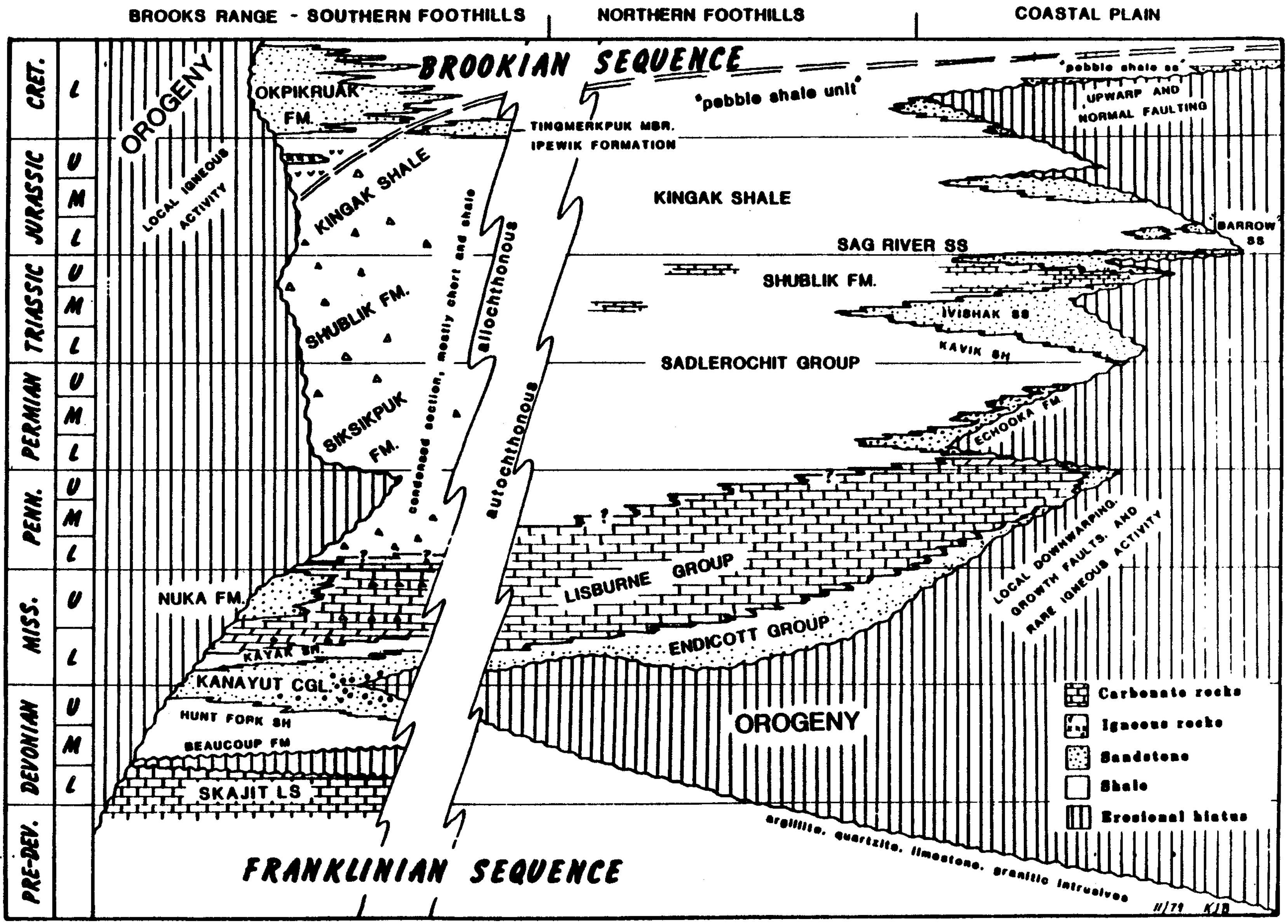


Figure 15. Time-stratigraphic diagram of the Ellesmerian sequence of the North Slope in Alaska (from Bird, 1981).

Upper Mississippian to Lower Permian

The carbonate rocks of the Lisburne Group unconformably overlie the Endicott Group. The Lisburne Group, rocks up to 3,900 feet thick in NPRA, range in age from 333 Ma to 258 Ma. This group is divided into two formations and one "zone." The Alapah Limestone is the older formation and is comprised of shallow-marine, thinly-bedded, shaley, dolomitic limestones. The upper portions of the Alapah are true dolomites. The Wahoo Limestone disconformably overlies the Alapah Limestone. The Wahoo comprises shallow-marine, massive limestone, and may be slightly dolomitic in the lower portions. The "transition zone" disconformably overlies the Wahoo Limestone, where it exists. The term "transition zone" has been applied to a mixture of clastic rocks and limestone that underlie the basal unconformity of the Sadlerochit Group in some areas.

Interbedded shallow-marine shale and limestone compose the Lisburne "transition zone." Limestone predominates in the basal portions and shale in the upper portion.

Upper Permian to Triassic

The Sadlerochit Group, 258 Ma to 240 Ma, unconformably overlies the Lisburne Group. The Sadlerochit Group, up to 700 feet thick, contains the Echooka and Ivishak formations. Glauconitic, fine-grained marine sandstone and marine shales with minor basal limestone compose the Echooka Formation. The fluvial and shallow marine sandstone, siltstone, and minor conglomerate of the Ivishak Formation disconformably overlies the Echooka Formation.

Triassic

The Shublik Formation conformably overlies the Sadlerochit Group. The Shublik Formation has an age of 240 Ma to 208 Ma, and is up to 600 feet thick in NPRA. Calcareous marine siltstone and shale compose the Shublik Formation except near the present day coastline between Barrow and Prudhoe Bay, where it contains abundant coquina (Bruyenzeel *et al.*, 1982).

Jurassic

The Sag River Sandstone conformably overlies the Shublik Formation. A 208 Ma to 187 Ma very fine- to fine-grained marine sandstone forms the Sag River Sandstone.

The Kingak Shale, 187 Ma to 144 Ma, unconformably overlies the Sag River Sandstone. Dark gray marine shale with occasional interbeds of sandstone and siltstone predominates the Kingak Shale. It has a maximum thickness of 2,900 feet in NPRA.

Cretaceous

The "Pebble shale" unconformably overlies the Kingak Shale. This unconformity is an excellent marker horizon in seismic work throughout the entire North Slope. A relatively thin (up to 700 feet), widespread sequence of highly organic, deep water marine shale with a fairly extensive basal sandstone forms the "Pebble shale." The shale portions contain rare to common "floating," well rounded, frosted quartz grains and chert pebbles, hence the name. The basal sand of the "Pebble shale" has been called a Kuparuk Sandstone equivalent by some workers (Brockway, 1983, and Legg, 1983a) and a Walakpa Sandstone equivalent by others (Patterson et al., 1982, and Bruyenzeel et al., 1982).

Brookian Sequence

The Brookian sequence rocks range in age from 119 Ma to the present. They include a sequence of marine, fluvial, lacustrine, eolian, and glacial sedimentary rocks with some volcanic ash components. The Brookian sequence rocks have a southern source.

Cretaceous

The Torok Formation unconformably overlies the "Pebble shale," and is between 119 Ma and 97 Ma. Massive thicknesses (up to 8,100 feet) of prodelta shale and siltstone with some sandstone in the basal portions compose the Torok Formation.

The Nanushuk Group conformably overlies and is coeval (deposited at the same time in different areas) with the Torok Formation. Up to 3,300 feet of intertonguing shallow-marine sandstones and neritic (marine sediment deposited in less than 600 feet of water) shale and siltstone deposited in a passive margin delta environment compose the 100 Ma to 93 Ma Nanushuk Group. Nonmarine shale, fluvial sandstone, and coal compose most of the upper portion of the Nanushuk Group.

The Colville Group is absent in western NPRA.

Tertiary

The Sagavanirktok Formation is absent in western NPRA.

Quaternary

The Gubik Formation ranges in age from 2 Ma to about 10,000 years old and unconformably overlies the Colville Group. The Gubik Formation has a thickness of up to 200 feet and may be locally absent. The Gubik is comprised primarily of clay, silt, and sand with minor gravel, and is ice rich.

A series of thaw lake deposits and undifferentiated fluvio-lacustrine (stream-lake) deposits with some minor marine sand, silt, and clay deposits overlies the Gubik Formation. All of the material overlying the Gubik Formation is less than 10,000 years old.

Stratigraphy -- Crystalline Rocks

Little is known about the crystalline rocks that underlie the Franklinian sequence in this area.

Geochemistry

Banet (1983) in his study of the Tunalik No. 1 well (Sec. 20, T. 10 N., R. 36 W., Umiat Meridian, approximately 20 miles southeast of Icy Cape) states that the Nanushuk Group and the Torok Formation are rich in gas prone organic material, and that the "Pebble shale" contains oil prone organic material, but that it is too deeply buried to produce oil and would produce gas instead. The data presented by Claypool and Magoon (1980) about the Kugrua No. 1 well (Sec. 8, T. 14 N., R. 26 W., Umiat Meridian, 23 miles south of Point Franklin) indicates that the "Pebble shale" may not be too deeply buried to generate oil.

Hydrocarbon Occurrence Potential

This area of Alaska Maritime NWR has a high hydrocarbon occurrence potential, a BLM mineral potential classification of H/C (figures 16 and 17). This classification is based on the geochemical investigations of the rocks in the area that indicate hydrocarbon generation is possible, and the gas shows in all three wells in NPRA closest to this area (Tunalik No. 1, Kugrua No. 1, and the Peard No. 1, Sec. 25, T. 16 N., R. 28 W., Umiat Meridian, about 15 miles south-southwest of Point Franklin).

Omalik Lagoon to Tasaychek Lagoon

The area of Alaska Maritime NWR between the Omalik Lagoon and Tasaychek Lagoon is part of the Arctic Foothills of the Brooks Range, and has geology similar to that of the National Petroleum Reserve in Alaska (NPRA). This area includes Ann Stevens/Cape Lisburne, Cape Thompson, and the barrier islands for Stepping Lagoon, Tasikpak Lagoon, Pusaluk Lagoon, Tugik Lagoon, and Kavrorak Lagoon.

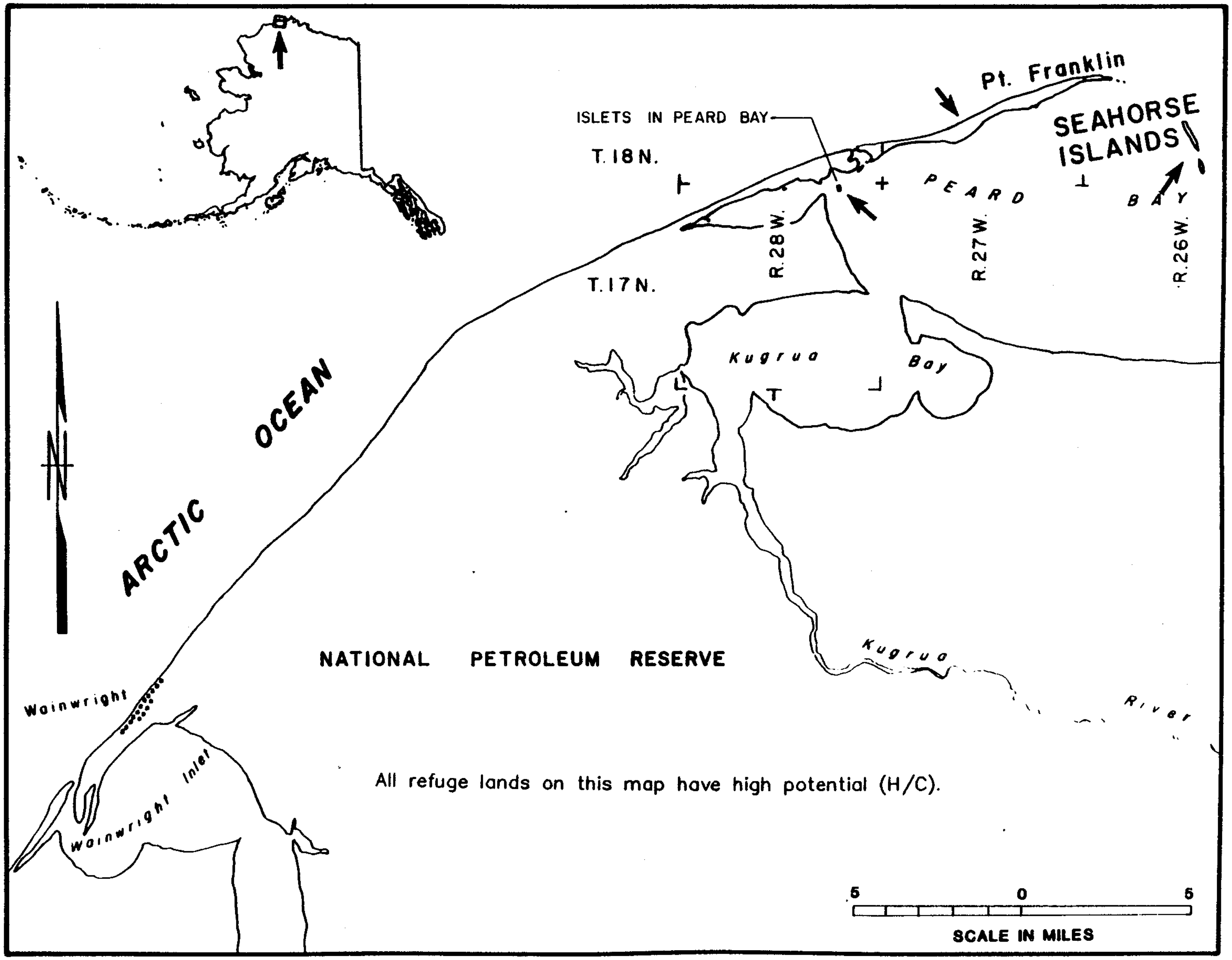


Figure 16. Hydrocarbon occurrence potential in the Chukchi Sea Unit, Seahorse Islands to Wainwright.

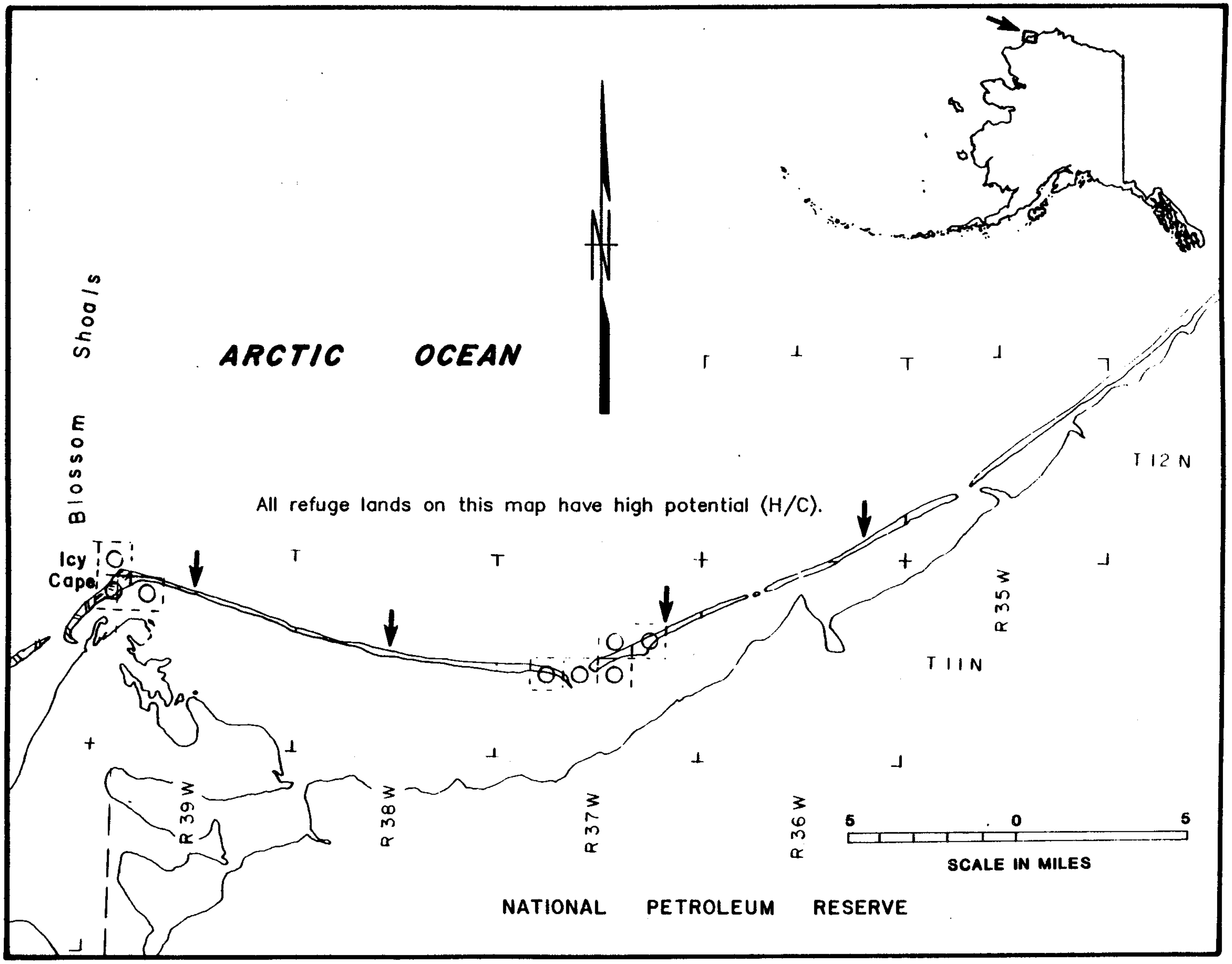


Figure 17. Hydrocarbon occurrence potential in the Chukchi Sea Unit, Wainwright to Icy Cape.

Geology

Stratigraphy -- Sedimentary Rocks

Many of the rock units in the Seahorse Islands to Omalik Lagoon portion of the refuge are also present in the section of the refuge extending from Omalik Lagoon to Tasaychek Lagoon. Figure 18 is a stratigraphic column for the Lisburne peninsula, and figure 19 is a cross section from near Tusikpak Lake on the Lisburne Peninsula to Selawik Lake.

Pre-Ordovician

Pre-Ordovician (greater than 505 Ma) rocks are not exposed in this area, and it is uncertain what underlies the exposed Ordovician rocks.

Ordovician to Silurian

The Ordovician to Silurian (505 Ma to 408 Ma) rocks exposed on Cape Lisburne are unnamed. Graywacke, mudstone, and calcareous shale compose these rocks.

Upper Devonian

The "Pebbly sandstone" unconformably overlies the unnamed Ordovician and Silurian rocks. This unit is approximately 374 Ma to 360 Ma.

Upper Devonian to Lower Mississippian

The Endicott Group conformably overlies the "Pebbly sandstone," and is from 374 Ma to 333 Ma. On the Lisburne Peninsula the Endicott Group comprises quartzite, shale, and minor coal. The upper portions of the Endicott Group contains some limestone.

Upper Mississippian to Lower Pennsylvanian

On the Lisburne Peninsula the Lisburne Group consists of the Nasorak Formation, the Kogruk(?) Formation, the Tupik Formation and the Kuna Formation, oldest to youngest. The Lisburne Group is from 333 Ma to 315(?) Ma. The Nasorak Formation comprises limestone interbedded with shaley limestone or calcareous shale. The Kogruk(?) Formation comprises dolomite and limestone with chert nodules. The Tupik Formation contains interbedded chert and limestone. The Kuna Formation is a black, carbonaceous shale.

Upper Pennsylvanian to Lower Jurassic

The Etivluk Group overlies the Lisburne Group, and is from 315(?) Ma to 187 Ma. The Siksikpuk Formation and the Otuk Formation compose the

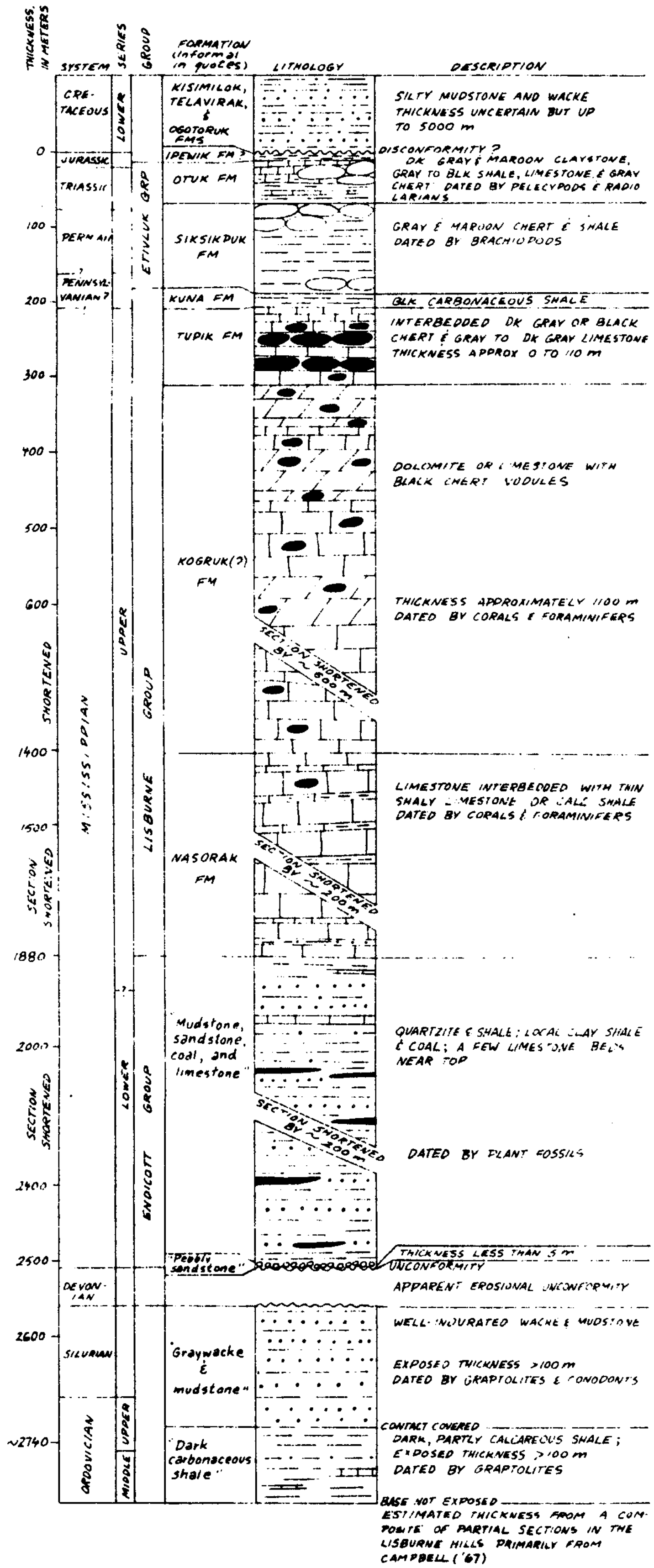


Figure 18. Stratigraphic column for Cape Lisburne (from Mayfield, Tailleur, and Ellersieck, 1983).

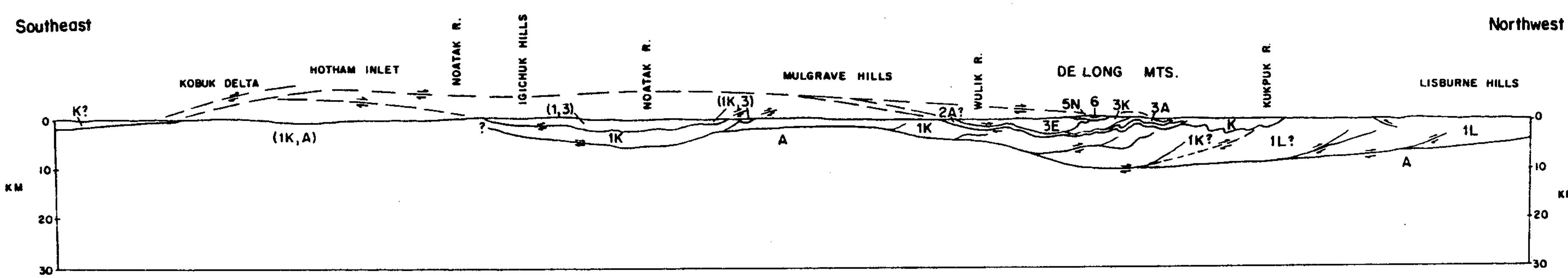


Figure 19. Cross section from the Lisburne Hills to the Kobuk Delta, looking south (from Mayfield, Tailleur, and Ellersieck, 1983).

Etivluk Group. The Siksikpuk Formation consists of chert and shale, and is Upper Pennsylvanian to Permian in age (315(?) Ma to 245 Ma). The Triassic to Lower Jurassic (245 Ma to 187 Ma) Otuk Formation comprises claystone, shale, limestone, and chert.

Middle Jurassic to Lower Cretaceous

The Kisimlok Formation, Telavirak Formation, and the Ogotoruk Formation are from Middle Jurassic to Lower Cretaceous (187 Ma to 98 Ma) in age. They comprise silty mudstone, and graywacke, and unconformably overlie the Etivluk Group. Mayfield et al. (1983) do not list the respective ages of these formations.

Upper Cretaceous to Quaternary

The Torok Formation, the Nanushuk Group, the Gubik Formation, and the more recent unnamed sediments, very much as described in the Seahorse Islands to Omalik Lagoon section, are present in this area.

Stratigraphy -- Crystalline Rocks

There is very little knowledge of the crystalline rocks near the coast in this area of the refuge.

Geochemistry

Although there is no direct information on the geochemistry of this area, it should be similar to that of the area from the Seahorse Islands to Omalik Lagoon.

Hydrocarbon Occurrence Potential

This area has a high hydrocarbon occurrence potential, a BLM mineral potential classification of H/C (figures 20 and 21). This classification is based on the good source potential of the rocks in the previous area that are also present in this area, and the probability that they have a similar geochemistry in this area.

Tasaychek Lagoon to Kiwalik Lagoon

The Alaska Maritime NWR between Tasaychek Lagoon and Kiwalik Lagoon is in the Kobuk-Selawik lowland. The geology of the area is the same as that discussed in the Selawik NWR Oil and Gas Assessment (Teseneer et al., 1988). This area includes Puffin Island, Chamiso Island, the Sinnachiak Peninsula, and the islands in Ekichuk Lake.

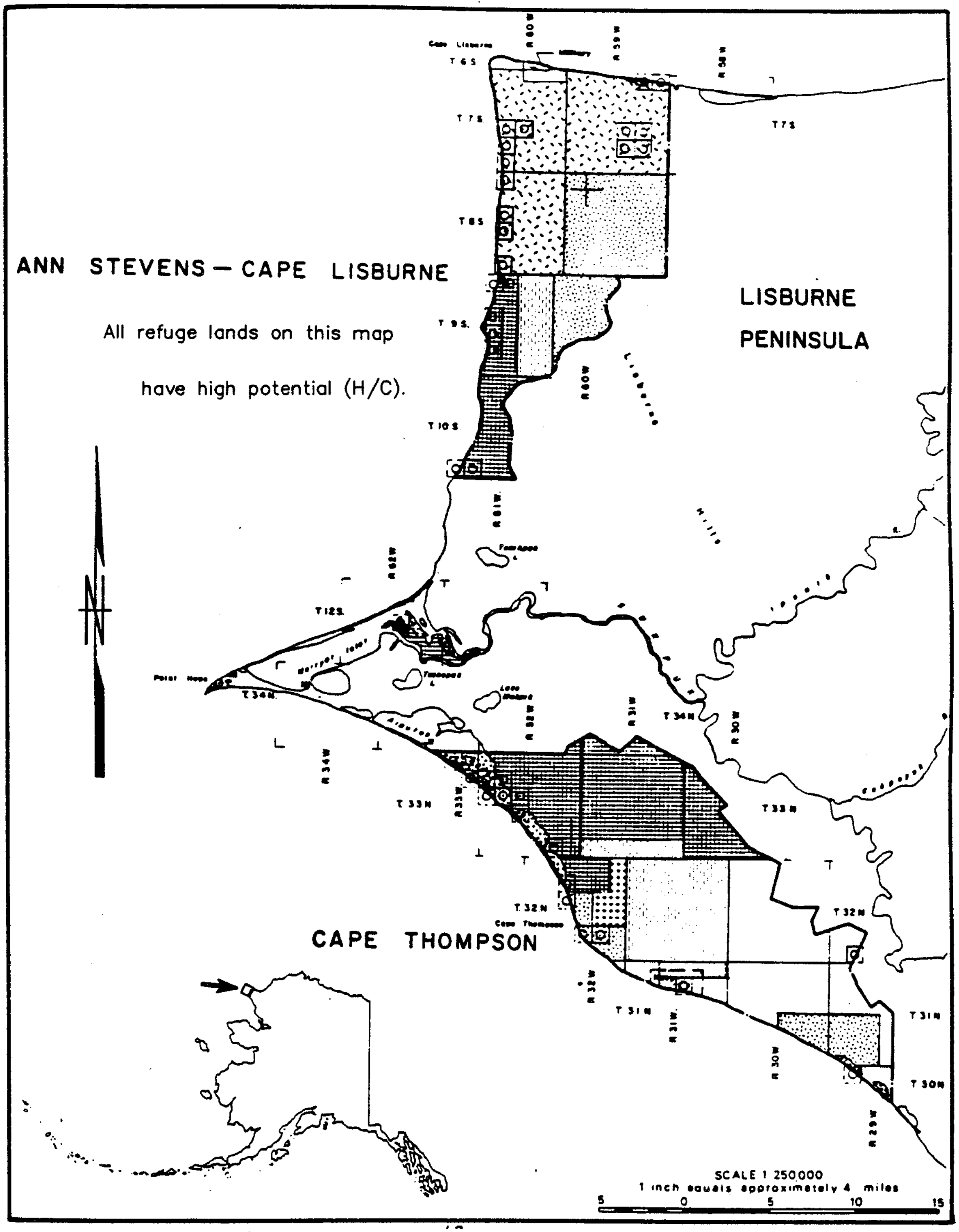


Figure 20. Hydrocarbon occurrence potential for the Chukchi Sea Unit, Cape Lisburne to the Cape Thomson area.

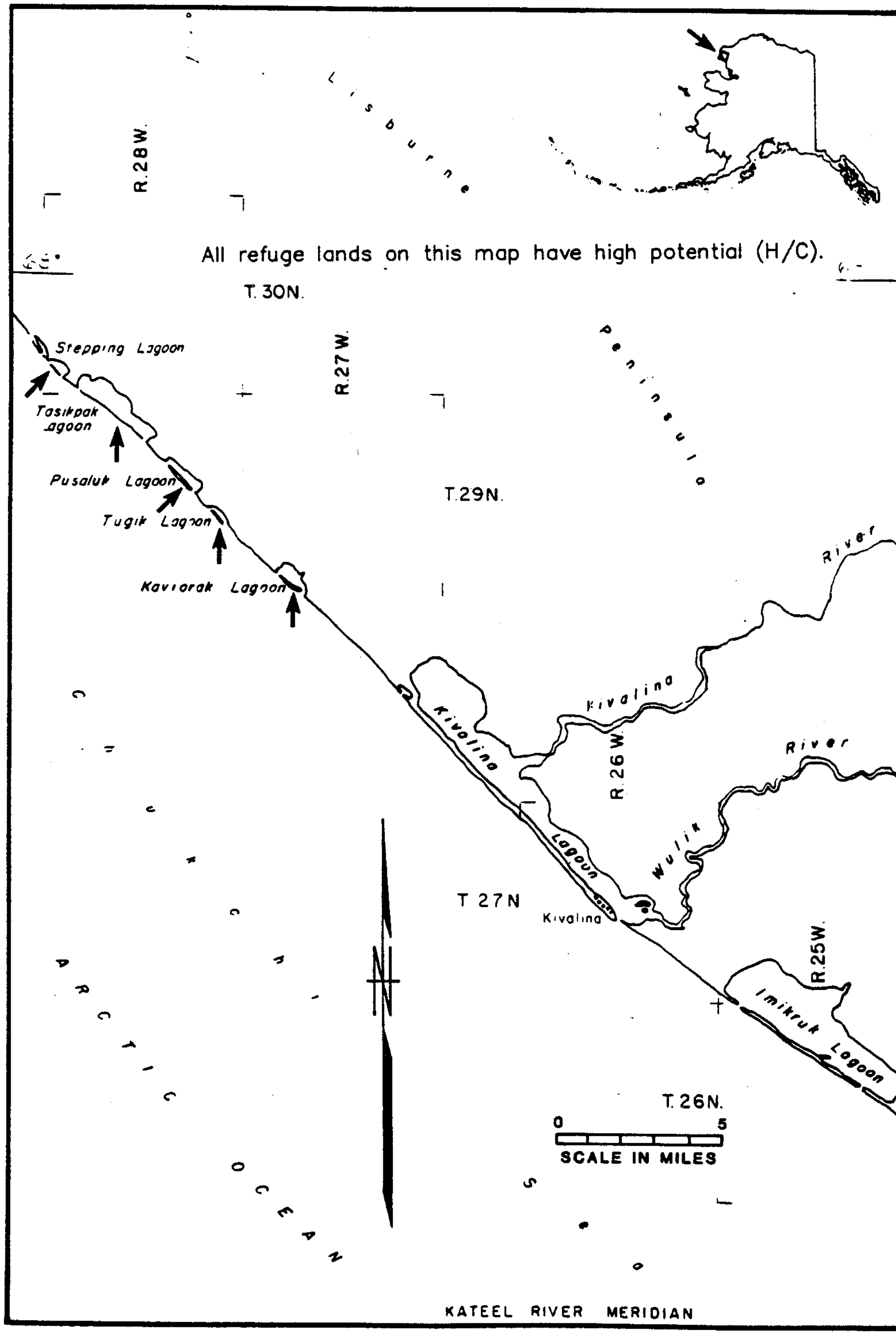


Figure 21. Hydrocarbon occurrence potential in the Chukchi Sea Unit, Stepping Lagoon to Imikruk Lagoon.

Geology

For a detailed description of geology in this area see the Selawik NWR Oil and Gas Assessment (Teseneer et al., 1988).

Geochemistry

For a detailed description of geochemistry in this area, see the Selawik NWR Oil and Gas Assessment (Teseneer et al., 1988).

Hydrocarbon Occurrence Potential

Puffin Island and Chamiso Island have a moderate hydrocarbon occurrence potential, a BLM mineral potential classification of M/C (figure 22). This classification is based on the sediments in this area that may provide a source and reservoir for hydrocarbon accumulation, the presence of gas on the Baldwin Peninsula, and the gas prone kerogens present in the sediments of the Selawik Basin. Both of these islands are within Selawik Basin.

The Ekichuk Lake islands have a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/A (figure 22) . This classification is based on the probable existence at shallow depths of Paleozoic metamorphic rocks.

The Sinnachiak Peninsula has a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/A (figure 22). This classification is based on the predominantly igneous and metamorphic nature of the rocks in this area. If this area is underlain by oceanic crust (as discussed in the Selawik NWR Oil and Gas Assessment) it would probably have no hydrocarbon occurrence potential. Although most evidence supports this theory, there is some evidence to the contrary, and if the area is underlain by continental crust, there would be a small chance of an accumulation of hydrocarbons.

Kiwalik Lagoon to the Southern Chukchi Sea Unit Boundary

This portion of the refuge lies entirely on the Seward Peninsula, and includes the Lopp Lagoon barrier islands. The following discussions will apply only to the area of Lopp Lagoon, rather than the entire Seward Peninsula.

Geology

Stratigraphy -- Sedimentary Rocks

Precambrian

The Precambrian rocks of the Lopp Lagoon area are probably all Upper Precambrian (2,500 Ma to 50 Ma) in age. They consist of thin-bedded rhythmically interbedded dolomitic limestone and argillaceous limestone, and slightly to moderately metamorphosed graphitic siltstone, slate, graywacke, and calcareous siltstone.

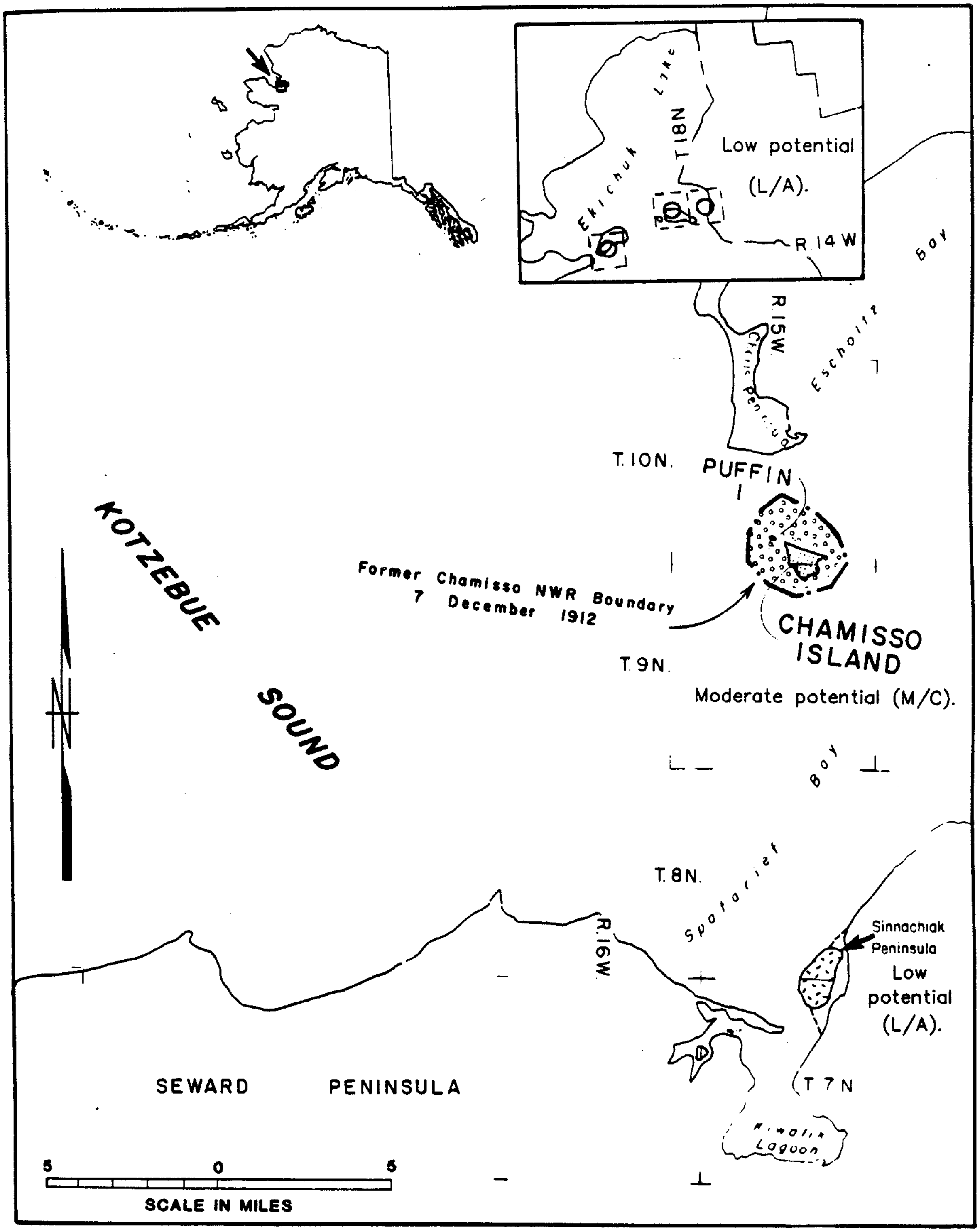


Figure 22. Hydrocarbon occurrence potential in the Chukchi Sea Unit, Ekichuk Lake and from the Baldwin Peninsula to Kiwalik Lagoon.

Lower Ordovician

The Lower Ordovician (505 Ma to 478 Ma) rocks of this area are thin-bedded argillaceous and silty limestone and dolomitic limestone, carbonaceous limestone, and subordinate massive micritic limestone which locally contains chert. A massive to thick-bedded limestone containing interbeds of argillaceous limestone, and sparse chert nodules in thick-bedded limestones overlie this unit.

Middle Ordovician

The Middle Ordovician (478 Ma to 458 Ma) rocks of this area comprise thin- to medium-bedded limestone with local chert nodules and a basal fissile black shale with minor interbedded limestone.

Mississippian

The Mississippian (360 Ma to 320 Ma) rocks of the Lopp Lagoon area comprise intensely deformed limestone and marble with interbeds of siliceous shale and local chert. Jones et al. (1987), equate these rocks to the Lisburne Group of northern Alaska.

Quaternary

The Quaternary sediments of this area are divided into two groups by relative age. The older, Pleistocene (1.6 Ma to 10,000 years old), sediments comprise terrace gravels, morainal deposits, loess, and fine-grained alluvium near streams and over coastal terraces. The younger, Holocene (10,000 years old or younger), sediments are tundra deposits and beach deposits on spits, bars, and in lagoons. The barrier islands for Lopp Lagoon comprise beach deposits.

Stratigraphy -- Crystalline Rocks

Precambrian

Coarse-grained gabbro and diabase compose the exposed Precambrian (greater than 570 Ma) crystalline rocks in this area.

Cretaceous

A medium- to coarse-grained biotite granite of Cretaceous age (144 Ma to 66 Ma) and small areal extent outcrops to the south of Lopp Lagoon.

Cretaceous to Tertiary

A series of dikes of Cretaceous to Tertiary age (144 Ma to 24 Ma) intrude Ordovician and older rocks of the area. The compositions of the dikes range from rhyolitic, to granitic, to diabasic, to lampyophyric.

Geochemistry

There is no petroleum geochemistry data available for this area.

Larson and Olsen (1984) indicate that gas prone source rocks occur in Kotzebue Sound north of this area, and Turner et al., (1986) indicate that both oil and gas prone source rocks occur in Norton Sound south of this area. Source rocks for hydrocarbons probably exist offshore from Lopp Lagoon.

Hydrocarbon Occurrence Potential

The barrier islands for Lopp Lagoon have a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/A (figure 23). This classification is based on the probability that the barrier islands are underlain by the igneous and metamorphic rocks exposed on the Seward Peninsula, modified by the possibility of offshore sediments extending landward of the present position of the barrier islands as stated by Sainsbury (1972).

Bering Sea Unit

Northern Bering Sea Unit Boundary to the Koyuk River

The portion of the Alaska Maritime NWR between the northern boundary of the Bering Sea Unit and the Koyuk River is part of the Seward tectonostratigraphic terrane. This area includes Sledge Island, Safety Sound barrier island, Topkok Head, Bluff, and Cape Darby.

Geology

Stratigraphy -- Sedimentary Rocks

Precambrian

Precambrian (570 Ma or older) age rocks between the northern Bering Sea Unit boundary and the Koyuk River include biotite-feldspar-quartz gneiss, marble, argillaceous limestone and dolomitic limestone, calc-schist, meta-graywacke, meta-siltstone, slate, phyllite, and phyllitic schist.

Paleozoic

Rocks of Paleozoic age (570 Ma to 245 Ma) in this area consist of calcareous and dolomitic marble with minor limestone, dolomitic limestone, dolomite, and clastic sedimentary rocks.

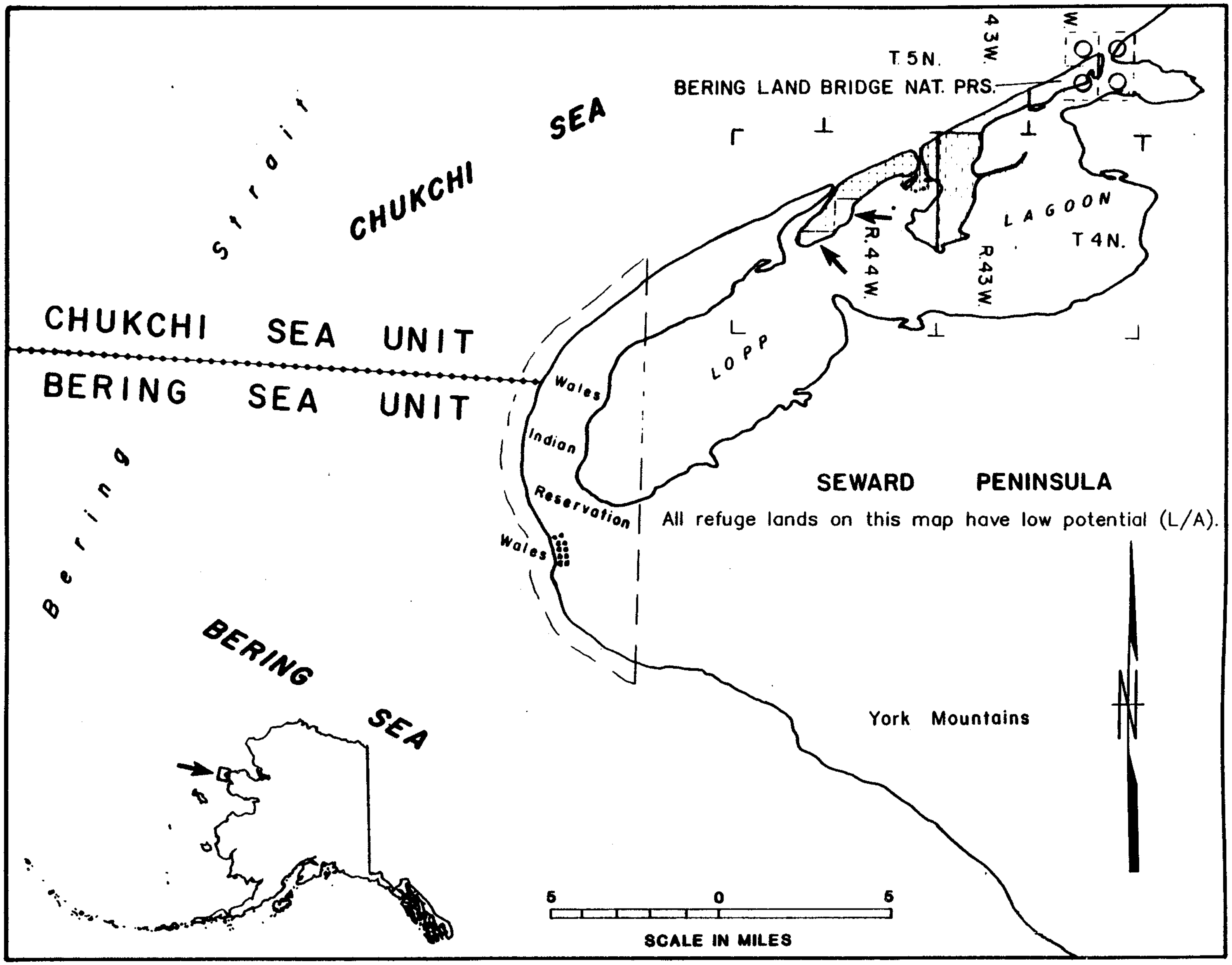


Figure 23. Hydrocarbon occurrence potential in the Chukchi Sea Unit, Lopp Lagoon.

Ordovician to Silurian

Ordovician to Silurian (505 Ma to 408 Ma) age rocks in this area include limestone, argillaceous limestone, and shale. These rocks may have a thickness exceeding 10,000 feet (Hudson, 1977).

Mississippian

Limestone, marble, and minor shale compose the Mississippian age (360 Ma to 320 Ma) rocks in this area.

Pre-Cretaceous

Undifferentiated pre-Cretaceous (greater than 144 Ma) rocks in this area include predominantly schists and marble.

Cretaceous to Tertiary

In this area, the Cretaceous to Tertiary (144 Ma to 1.6 Ma) rocks are nonmarine conglomerate, sandstone, siltstone, shale, claystone, and coal. Impure calcareous rocks are locally present.

Quaternary

Rocks or sedimentary deposits of Quaternary age (less than 1.6 Ma) are comprised of silt, sand, gravel, glacial drift, tundra deposits, and beach related sand and gravel deposits.

Stratigraphy -- Crystalline Rocks

Precambrian

Metamorphosed volcanic rocks with minor metamorphosed mafic intrusive rocks, and granitic gneiss compose the Precambrian (older than 570 Ma) crystalline rocks in this area of the Bering Sea Unit. The volcanic rocks and mafic intrusives are now predominantly greenschist.

Cretaceous

Crystalline rocks of Cretaceous age (144 Ma to 66 Ma) are comprised of biotite granite, and granodiorite.

Tertiary to Quaternary

Tertiary to Quaternary age (66 Ma to recent) crystalline rocks of the area consists predominantly of olivine basalt with minor amounts of breccia, scoria, tuff, and cinder deposits.

Geochemistry

There is very limited petroleum geochemistry data available for the onshore portions of this area; however, much work has been done offshore in the Norton basin.

The geochemistry of the Norton basin and the limited onshore information tend to indicate that the rocks of the area contain gas prone kerogen which ranges from immature to mature for Tertiary age rocks and to over mature for Cretaceous or older rocks.

Hydrocarbon Occurrence Potential

This entire area, except Sledge Island, has a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/A (figures 24 and 25). This classification is based on the occurrence of oil and gas seeps and some oil shale along the southern coast of the Seward Peninsula, a gas show in a well drilled near Nome, and the geochemistry of the Norton basin and the onshore Tertiary rocks (Turner et al., 1986).

Sledge Island has no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 24). This classification is based on the granitic nature of Sledge Island (Hudson, 1977).

Koyuk River to Kinak Bay

All of this part of the Bering Sea Unit is within the Yukon-Koyukuk tectonostratigraphic terrane (province) and much of the area is adjacent to the Yukon Delta NWR. The geology of the Yukon-Koyukuk province has been discussed in the oil and gas assessments of the Selawik NWR and the Yukon Delta and Togiak NWR's (Teseneer et al., 1988; Gibson et al., 1988). This area includes Besboro Island, Egg Island, Whale Island, Beulah Island, Cape Stephens, and the Sand Islands (Krekatok Island and Neragon Island).

Geology

For a detailed description of geology in this area see the Selawik NWR Oil and Gas Assessment (Teseneer et al., 1988) and the Oil and Gas Assessment of the Yukon Delta and Togiak NWR's (Gibson et al., 1988).

Geochemistry

For a detailed description of geochemistry in this area, see the Oil and Gas Assessment of the Yukon Delta and Togiak NWR's (Gibson et al., 1988).

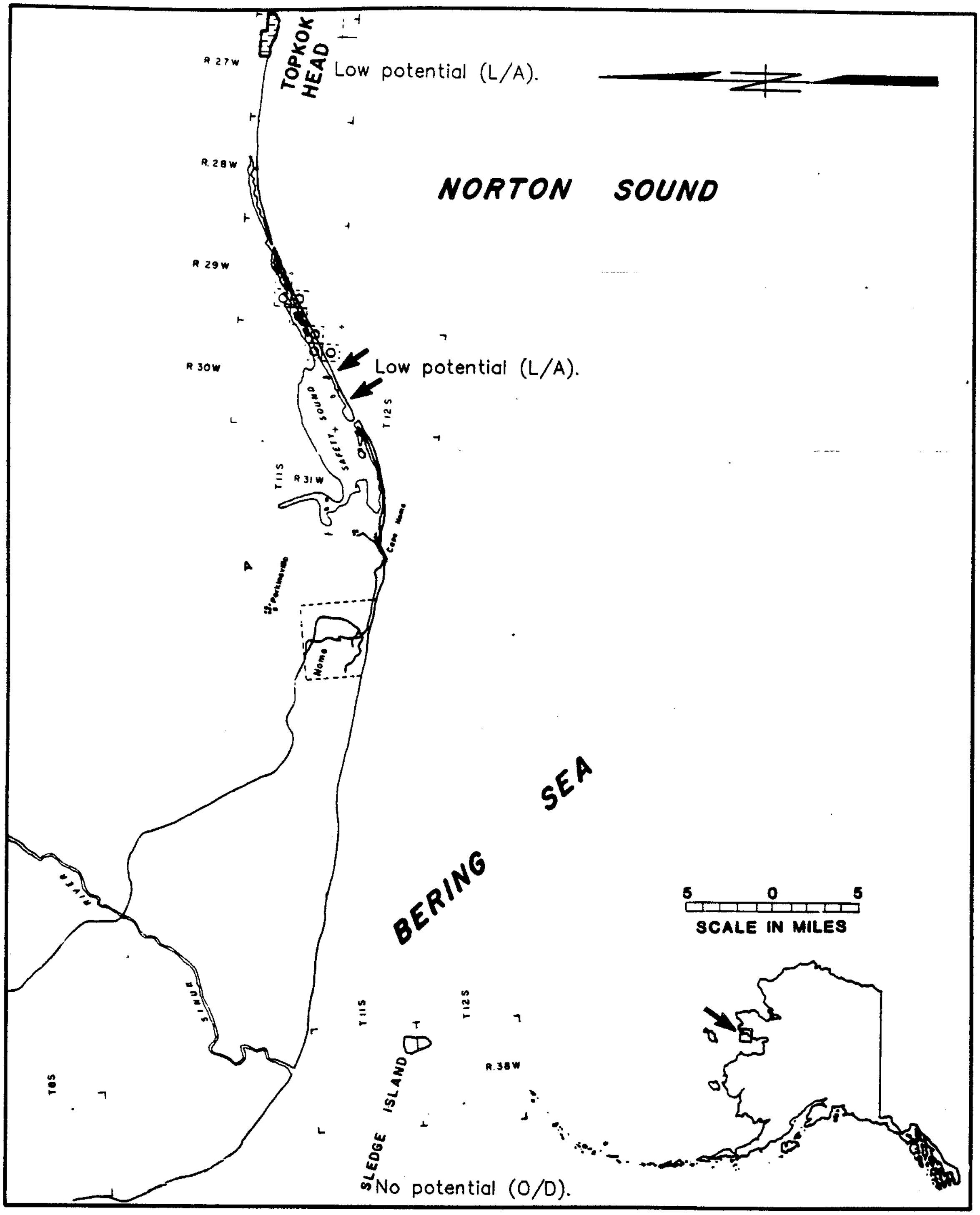


Figure 24. Hydrocarbon occurrence potential in the Bering Sea Unit, Sinuk River to Topkok Head.

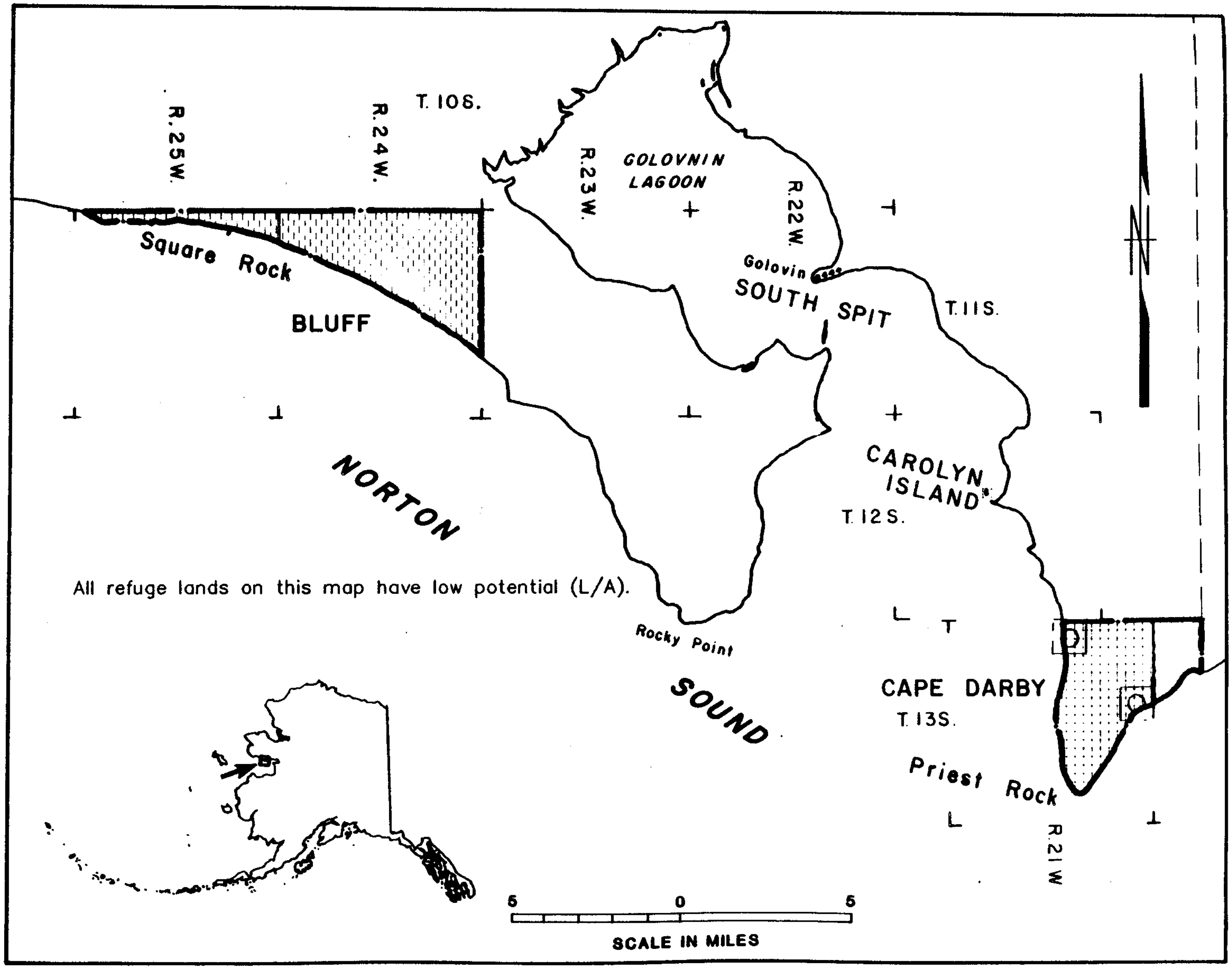


Figure 25. Hydrocarbon occurrence potential in the Bering Sea Unit, Square Rock to Cape Derby.

Hydrocarbon Occurrence Potential

This area of the Bering Sea Unit has a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/B (figures 26, 27, and 28). See the Oil and Gas Assessment of the Yukon Delta and Togiak NWR's (Gibson et al., 1988) for the basis of this classification.

Kinak Bay to Kanektok River

The area of the Alaska Maritime NWR between Kinak Bay and Kanektok River is in the Bethel basin and is discussed in the Oil and Gas Assessment of the Yukon Delta and Togiak NWR's (Gibson et al., 1988). This area includes Kikegtak Island, Pingurbek Island, and Kwigluk Island.

Geology

For a detailed description of geology in this area see the Oil and Gas Assessment of the Yukon Delta and Togiak NWR's (Gibson et al., 1988).

Geochemistry

For a detailed description of geochemistry in this area, see the Oil and Gas Assessment of the Yukon Delta and Togiak NWR's (Gibson et al., 1988).

Hydrocarbon Occurrence Potential

This area of the Bering Sea Unit has a moderate hydrocarbon occurrence potential, a BLM mineral potential classification of M/A (figure 28). See the Oil and Gas Assessment of the Yukon Delta and Togiak NWR's (Gibson et al., 1988) for the basis of this classification.

Northern Jacksmith Bay to Tvativak Bay

The portion of Alaska Maritime NWR between northern Jacksmith Bay and Tvativak Bay is underlain by the Togiak, Goodnews, Kilbuk, and Nyac tectonostratigraphic terranes. This area includes Hagemeister Island.

Geology

For a detailed description of geology in this area, see the Oil and Gas Assessment of the Yukon Delta and Togiak NWR's (Gibson et al., 1988).

Geochemistry

For a detailed description of geochemistry in this area, see the Oil and Gas Assessment of the Yukon Delta and Togiak NWR's (Gibson et al., 1988).

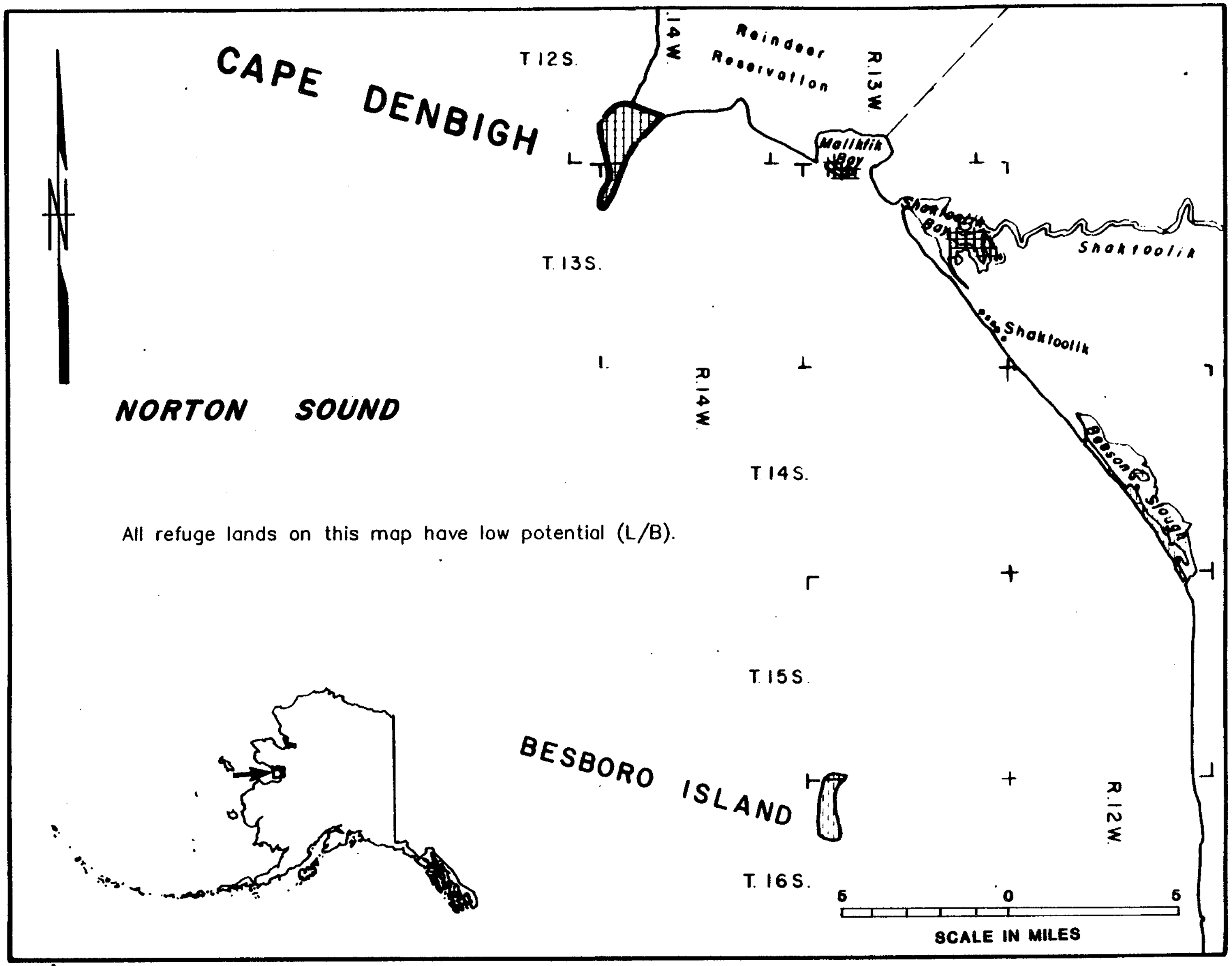


Figure 26. Hydrocarbon occurrence potential in the Bering Sea Unit, Cape Denbigh to Besboro Island.

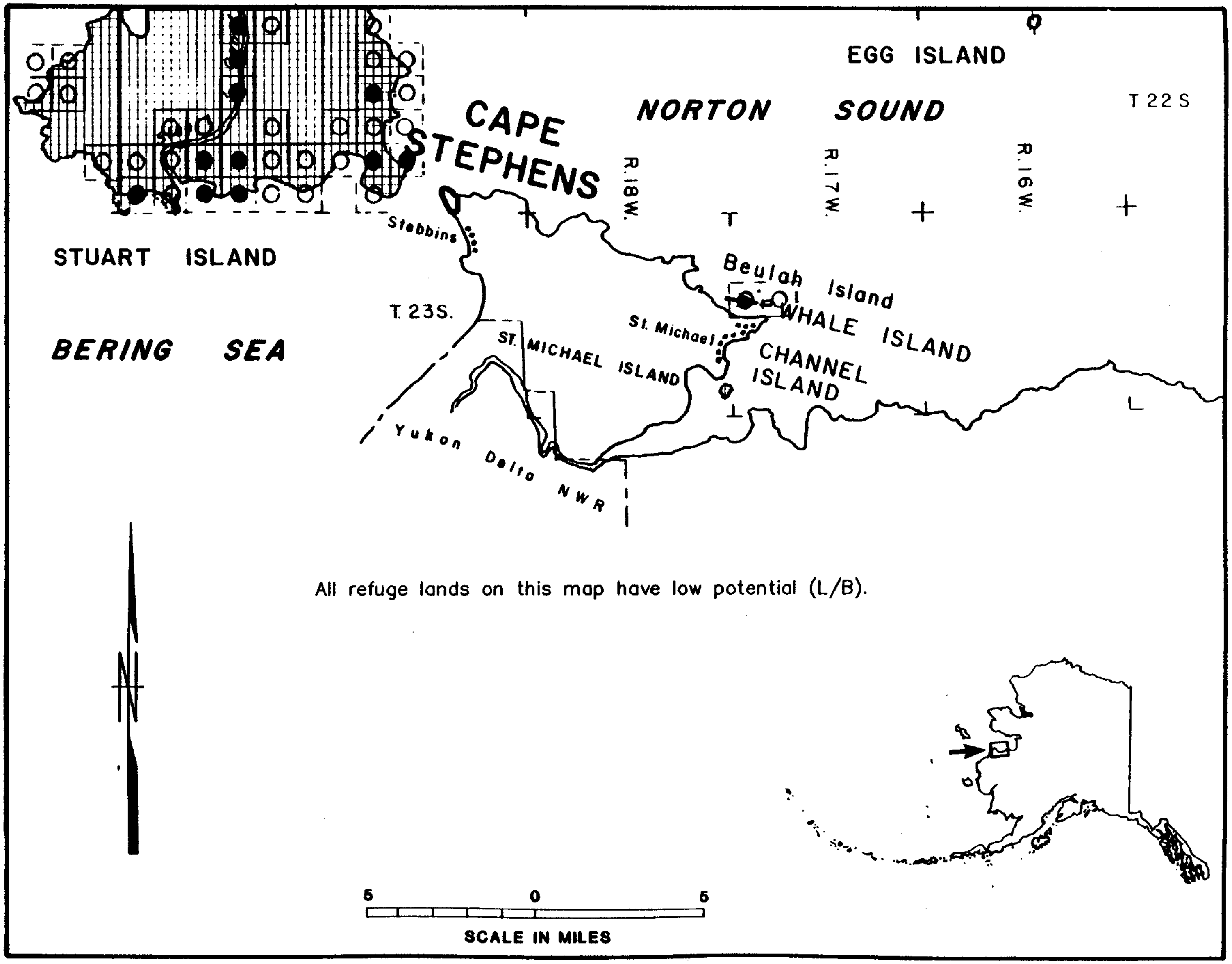


Figure 27. Hydrocarbon occurrence potential in the Bering Sea Unit, Egg Island to Cape Stephens.

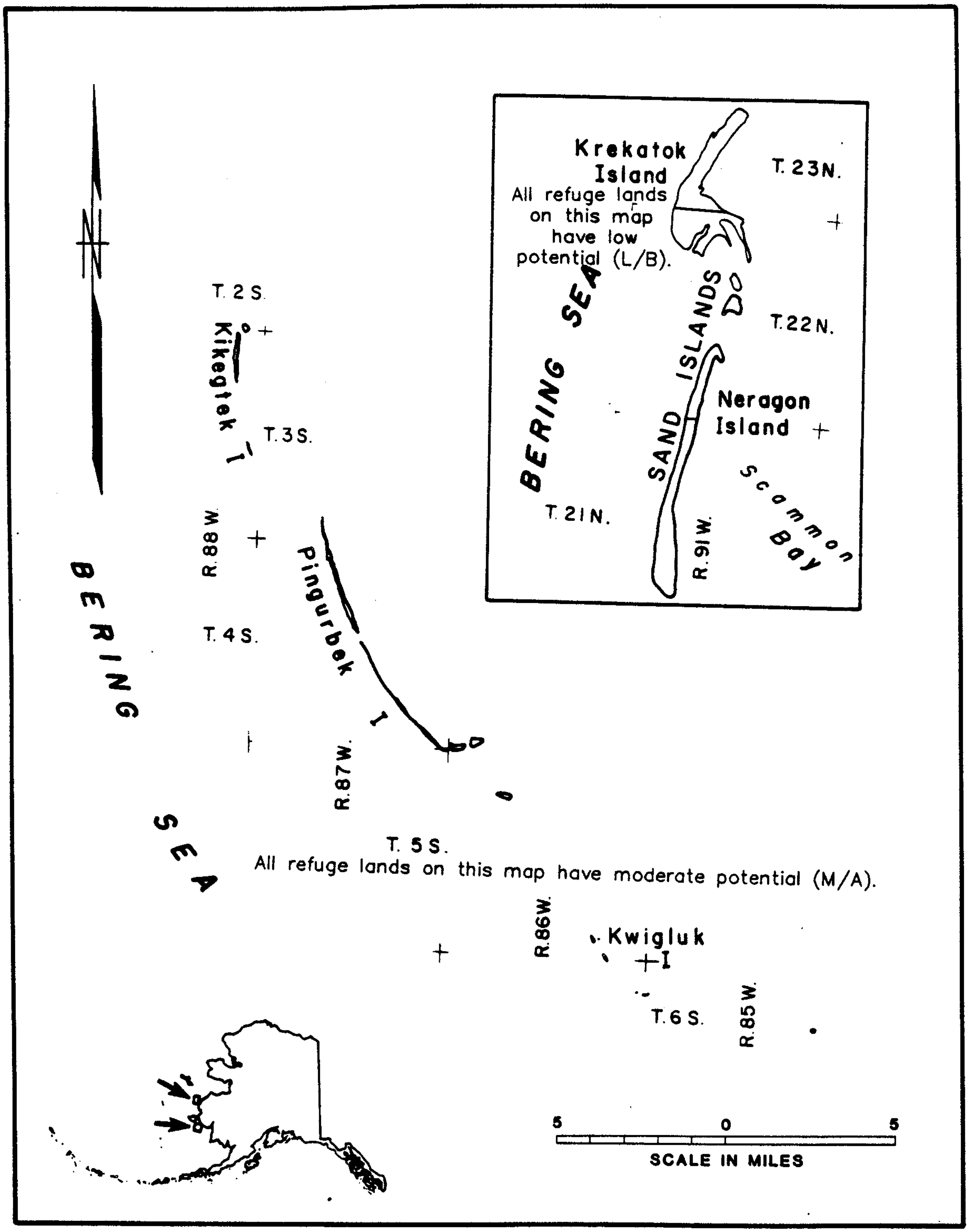


Figure 28. Hydrocarbon occurrence potential in the Bering Sea Unit, Krekatok Island to Kwigluk Island.

Hydrocarbon Occurrence Potential

This area of the Bering Sea Unit has been given no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 29). See the Oil and Gas Assessment of the Yukon Delta and Togiak NWR's (Gibson et al., 1988) for the basis of this classification.

St. Matthew Island Group

The St. Matthew Island Group lies in the Bering Sea southwest of Norton Sound and east of the Yukon-Kuskokwim delta. The island group includes Hall Island, St. Matthew Island, and Pinnacle Island.

Geology

The St. Matthew Island Group lies in the Okhotsk-Chukotsk volcanic belt, between Norton and Navarin basins (figure 30 and 31). Most of the exposed rocks on the St. Matthew Island Group are volcanic. A small portion of Hall Island and a small portion St. Matthew Island were not mapped. There are apparently no sedimentary rocks on Pinnacle Island (Patton, Miller et al., 1975).

Stratigraphy -- Sedimentary Rocks

Cretaceous

Cretaceous (144 Ma to 66 Ma) rocks on the St. Matthew Island Group are comprised of volcanic graywacke and argillite.

Quaternary

Quaternary (1.6 Ma or younger) deposits on the island group are limited to beach, bar, alluvial and colluvial deposits, that are mostly gravel and sand.

Stratigraphy -- Crystalline Rocks

Cretaceous

Cretaceous (144 Ma to 66 Ma) crystalline rocks on the island group are comprised of dacitic, andesitic, and rhyolitic tuff breccia and crystal tuff; dacitic and rhyolitic welded tuff; massive dacite breccia (lahar?); fine ash-fall tuff; volcanic conglomerate; and andesitic and dacitic porphyritic and vitrophyritic plugs, dikes, sills, and flows with intercalated andesite and basalt flows in the upper part.

Cretaceous to Tertiary

Cretaceous to Tertiary (144 Ma to 1.6 Ma) crystalline rocks on St. Matthew Island are chiefly andesite and basalt flows with some volcaniclastic deposits

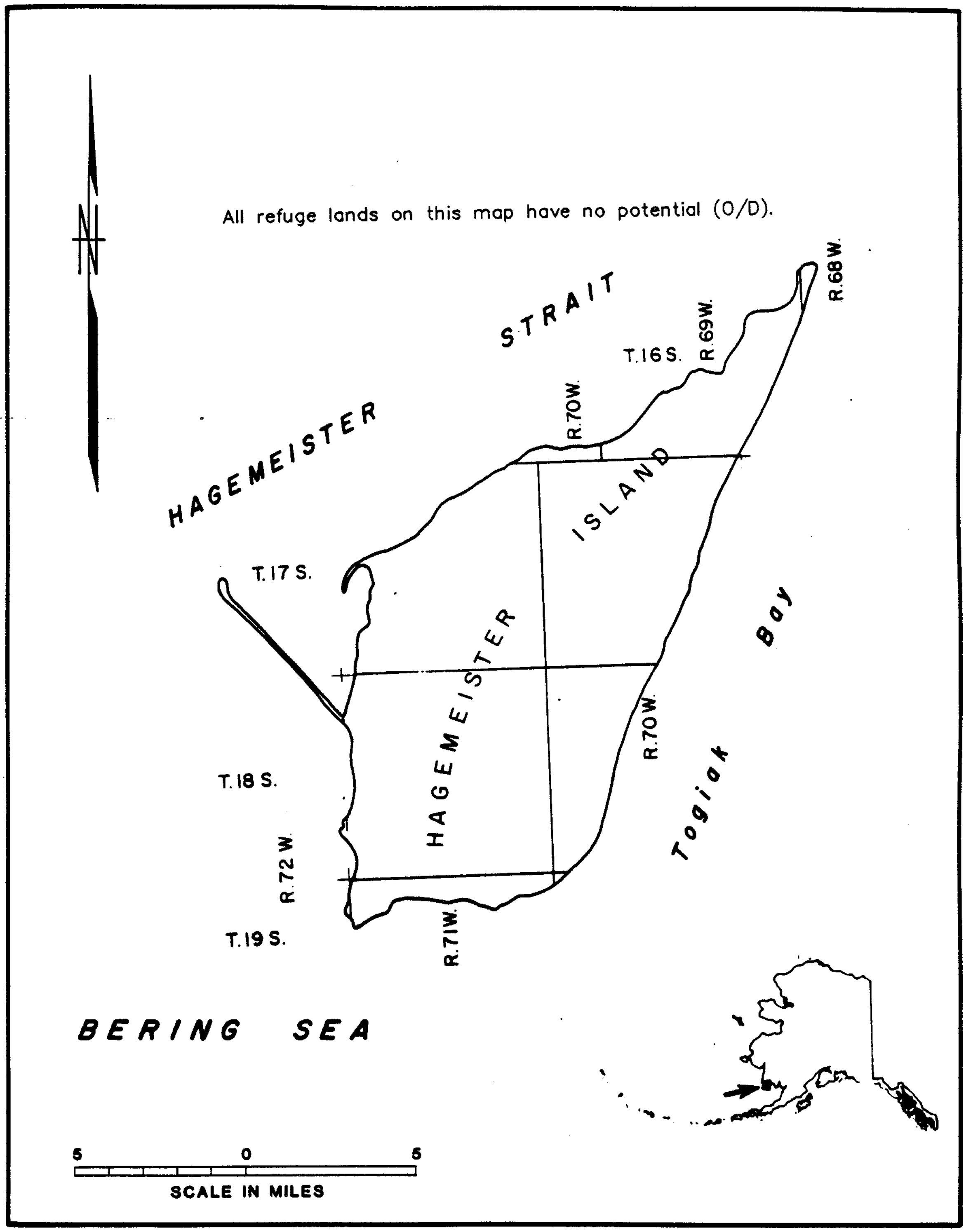


Figure 29. Hydrocarbon occurrence potential in the Bering Sea Unit, Hagemeister Island.

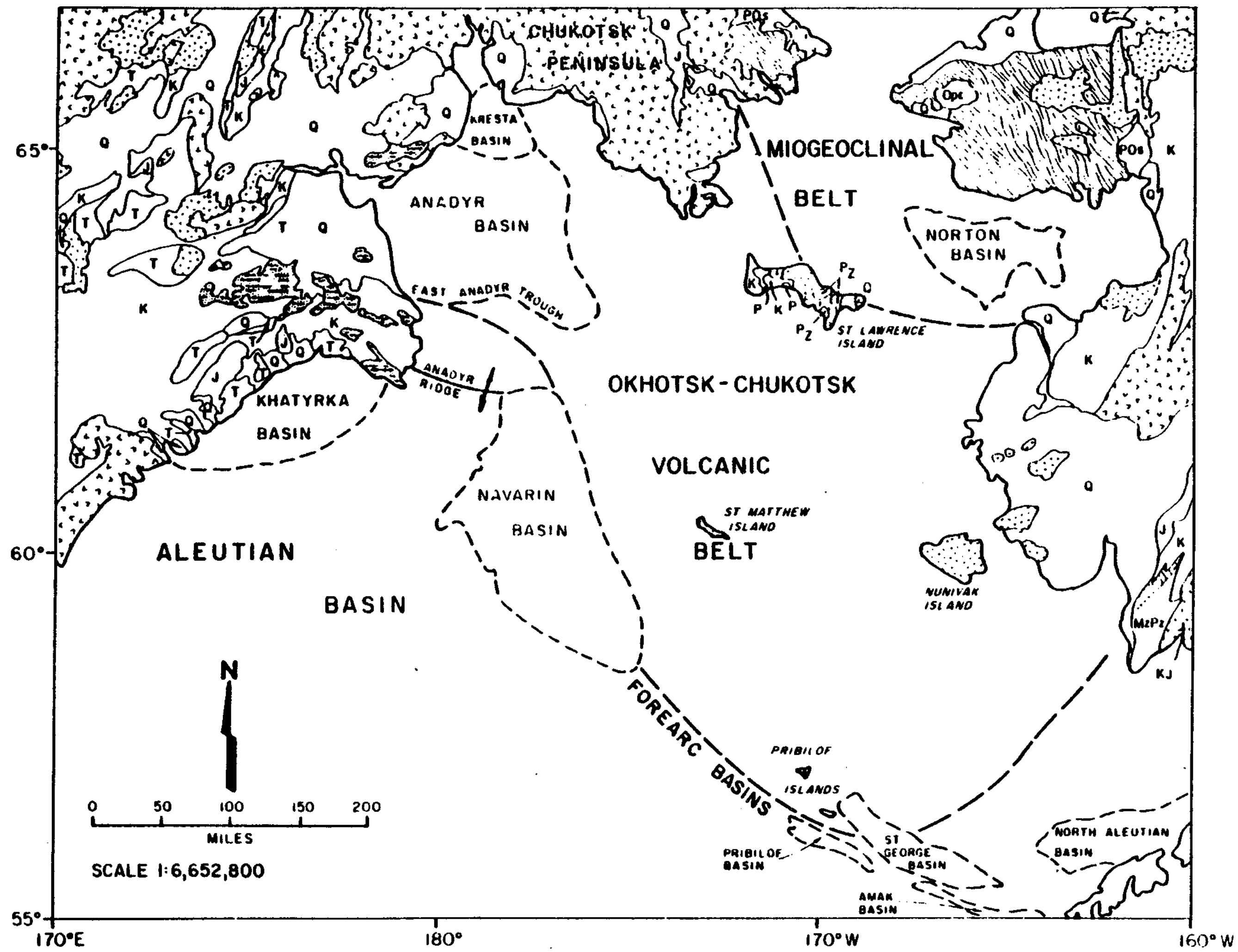
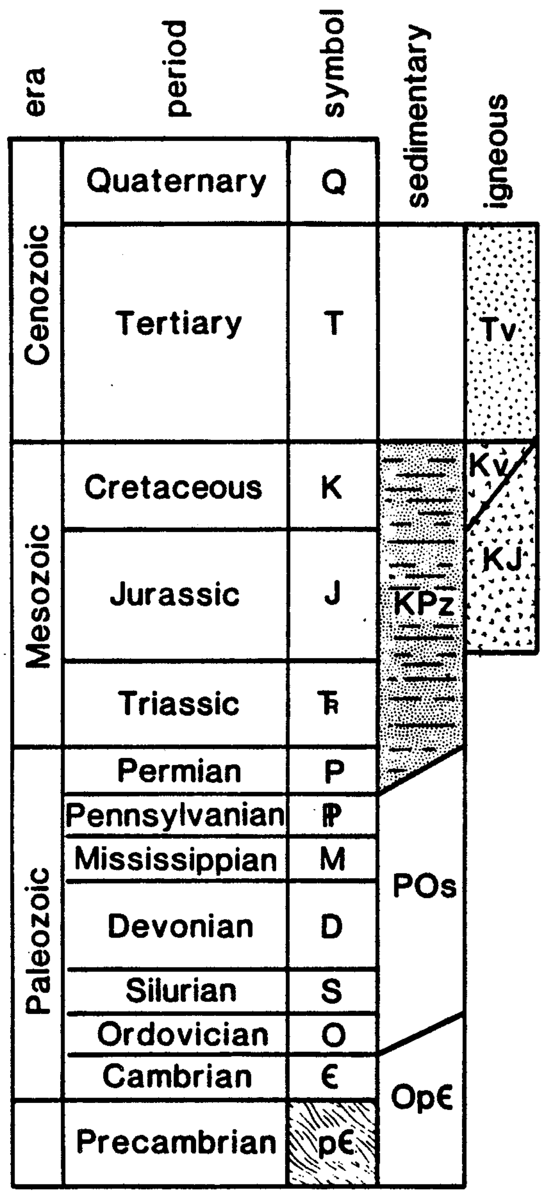


Figure 30. Map showing the Okhotsk-Chukotsk volcanic belt, and the locations of St. Matthew Island, and the Pribilof Islands within the belt. See figure 31 for the explanation and geologic column. (from Turner et al., 1986).



Tv: undifferentiated volcanic rocks.

Kv: undifferentiated volcanic rocks.

KJ: lava, tuff, agglomerate, argillite, shale, graywacke, quartzite, and conglomerate. Slightly metamorphosed in places.

KPz: south of 64° N latitude sandstone, siltstone, limestone, chert, and volcaniclastic rocks of Permian through Late Cretaceous age. Locally includes melange and olistostrome sequences. North of 64° N latitude are sandstone, siltstone, argillite, conglomerate, coal, spilite, and basalt.

POs: sedimentary rocks of Permian and Mississippian age. Includes some Ordovician, Silurian, and Mississippian limestone.

Op€: phyllite, sandstone, siltstone, limestone, chert, and quartzite.

p€: undifferentiated metasedimentary and metamorphic rocks.

Figure 31. Explanation and geologic column for figure 30 (from Turner et al., 1986).

of tuff and conglomerate. Medium- to coarse-grained gabbro dikes have intruded these rocks. On Hall Island the rocks are andesite and basalt flows intercalated with fine crystal tuff, coarse tuff breccia, and volcanic conglomerate. Pinnacle Island is comprised of nearly vertical mafic dikes.

Tertiary

Tertiary (66 Ma to 1.6 Ma) crystalline rocks are present on St. Matthew Island only. They are comprised of granodiorite, rhyolite, and dacitic tuff, with minor intercalated flows and crosscutting dikes of andesite and basalt.

Geochemistry

There is no petroleum geochemistry data available for the onshore portions of the St. Matthew Island Group. Offshore geochemical data from the Navarin basin (Carlson et al., 1985) suggest that the sediments offshore from the island group may have some hydrocarbon potential.

Hydrocarbon Occurrence Potential

The St. Matthew Island Group have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 32). This is based on the fact that all of the rocks on the islands are either igneous in nature or are sedimentary deposits of closely associated volcanic origin.

Pribilof Islands

The Pribilof Islands are located in the Bering Sea south-southeast of St. Matthew Island, and south-southwest of Nunivak Island. The islands include St. Paul Island, Walrus Island, Otter Island, and St. George Island.

Geology

The Pribilof Islands lie in the southern portion of the Okhotsk-Chukotsk volcanic belt, with geology similar to that of the St. Matthew Island Group.

Stratigraphy -- Sedimentary Rocks

Unknown age

At least 325 feet of sediments of unknown age and composition occur on Otter Island (Barth, 1956).

Quaternary

Recently formed alluvial deposits, mostly sand, and some earlier glacial deposits, are the only sediments on St. Paul Island. St. George Island has some sediments that range in composition from clay, to sand, to glacial till. All sediments on both islands are Quaternary (1.6 Ma or younger) in age.

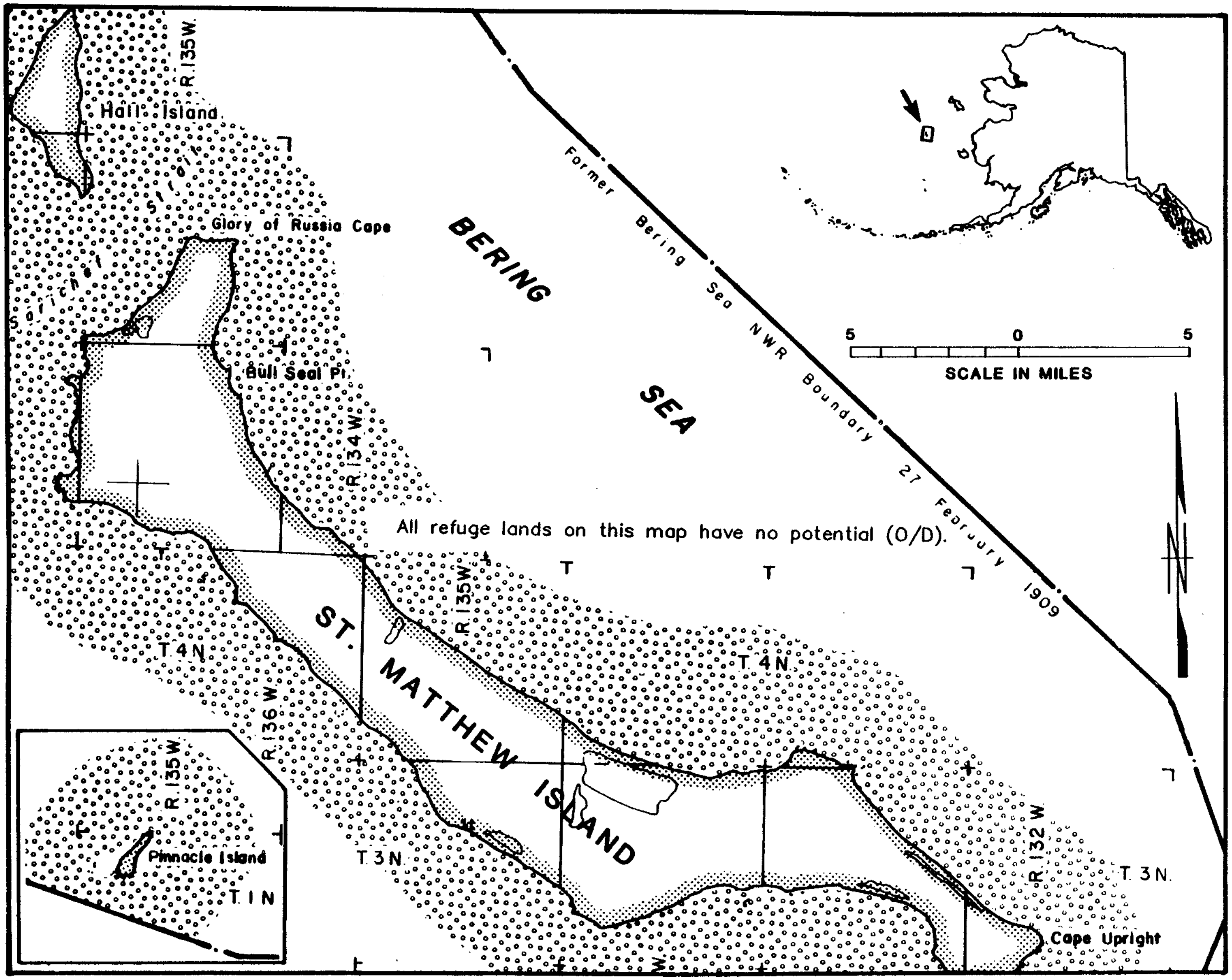


Figure 32. Hydrocarbon occurrence potential in the Bering Sea Unit, St. Matthew Island Group.

Stratigraphy -- Crystalline Rocks

Unknown age

Peridotite of unknown age occurs on St. George Island. An aplite granite, also on unknown age, intrudes the peridotite.

Tertiary to Quaternary

Crystalline rocks of Tertiary to Quaternary (66 Ma to recent) age in the Pribilof Islands comprise basalt flows.

Quaternary

Quaternary (1.6 Ma to recent) age crystalline rocks in the Pribilof Islands comprise basalt flows and pyroclastic deposits.

Geochemistry

There is no petroleum geochemistry data available for the onshore portions of the Pribilof Islands. Offshore geochemical data from the St. George basin (Cooper, Scholl, Vallier, and Scott, 1985) suggest that the sediments offshore from the island group may have some hydrocarbon potential.

Hydrocarbon Occurrence Potential

The Pribilof Islands have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 33). This is based on the fact that all of the rocks on the islands are either igneous in nature or are sedimentary deposits of closely associated volcanic origin.

Aleutian Islands Unit

Near Islands

The Near Islands are the westernmost island group in the Aleutian Islands chain. They include Attu Island, Agattu Island, Alaid Island, Nizki Island, and Shemya Island.

Geology

Although the Near Islands are part of the Aleutian volcanic island arc, they have, however, had no Holocene (younger than 10,000 years old) volcanic activity (Kienle, 1983), but are comprised largely of igneous rocks and various sediments (Beikman, 1980). Geologic mapping on Attu, Agattu, and Shemya islands indicate that they are comprised almost entirely of intrusive and extrusive igneous rocks and sediments from igneous sources (Gates et al., 1955). Alaid Island and Nizki Island have not been mapped in detail, but their geology is apparently similar to that of the other three islands (Beikman, 1980).

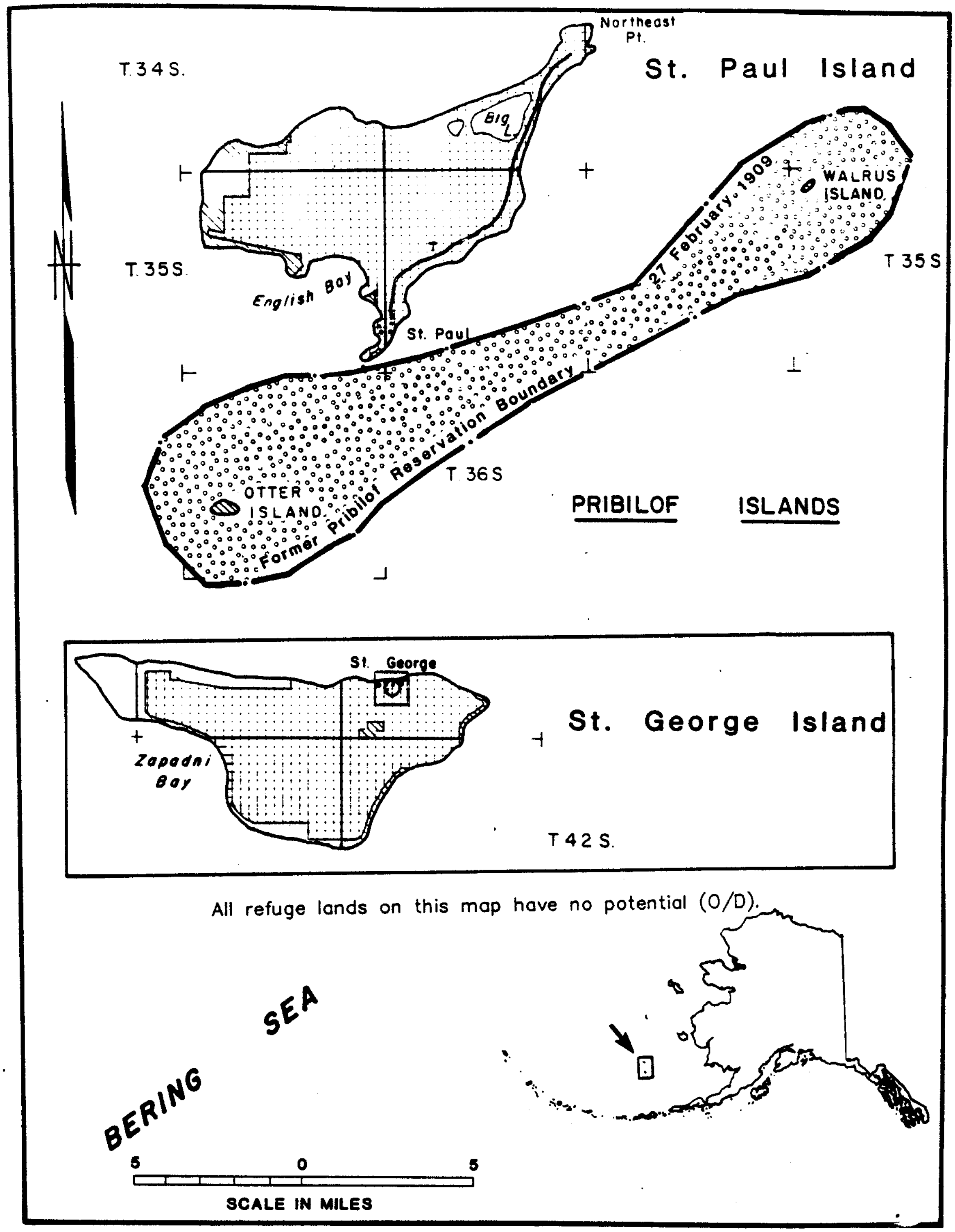


Figure 33. Hydrocarbon occurrence potential in the Bering Sea Unit, Pribilof Islands.

Geochemistry

There is no petroleum geochemistry data for the Near Islands. Geochemical data for the areas offshore the Aleutian Islands are encouraging for offshore oil development (Cooper, Scholl, Marlow et al., 1979). Scholl et al., (1976) indicate that summit basins along the Aleutian ridge may be good exploration targets; however, Stewart (1978) states that the sediments near the Aleutian Islands may not make adequate reservoirs.

Hydrocarbon Occurrence Potential

The Near Islands have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 34). This classification is based on the overwhelmingly igneous nature of the islands.

Rat Islands

The Rat Islands are located in the Aleutian Islands to the east of the Near Islands. They include Buldir Island, Kiska Island, Sobaka Rock, Little Kiska Island, Tanadak Island, Segula Island, Khvostof Island, Pyramid Island, Davidof Island, Rat Island, Little Sitkin Island, Amchitka Island, Bird Rock, and Semisopochnoi Island.

Geology

Snyder (1955), Nelson (1955), Coats (1955e), Powers et al. (1955), Lewis et al. (1955), and Coats, et al. (1955) geologically mapped Little Sitkin, Khvostof, Pyramid, Davidof, Segula, Semisopochnoi, Amchitka, Rat, Kiska, and Little Kiska islands in some detail This mapping shows that these islands are predominately volcanic in nature. All sediments on the islands are derived from volcanic rocks. The geology of the remainder of the islands in the Rat Islands is similar to that of the mapped islands (Beikman, 1980).

Geochemistry

There is no petroleum geochemistry data for the Rat Islands. Geochemical data for the areas offshore the Aleutian Islands are encouraging for offshore oil development (Cooper, Scholl, Marlow et al., 1979). Scholl et al., (1976) indicate that summit basins along the Aleutian ridge may be good exploration targets; however, Stewart (1978) states that the sediments near the Aleutian Islands may not make adequate reservoirs.

Hydrocarbon Occurrence Potential

The Rat Islands have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 34). This classification is based on the overwhelmingly igneous nature of the islands.

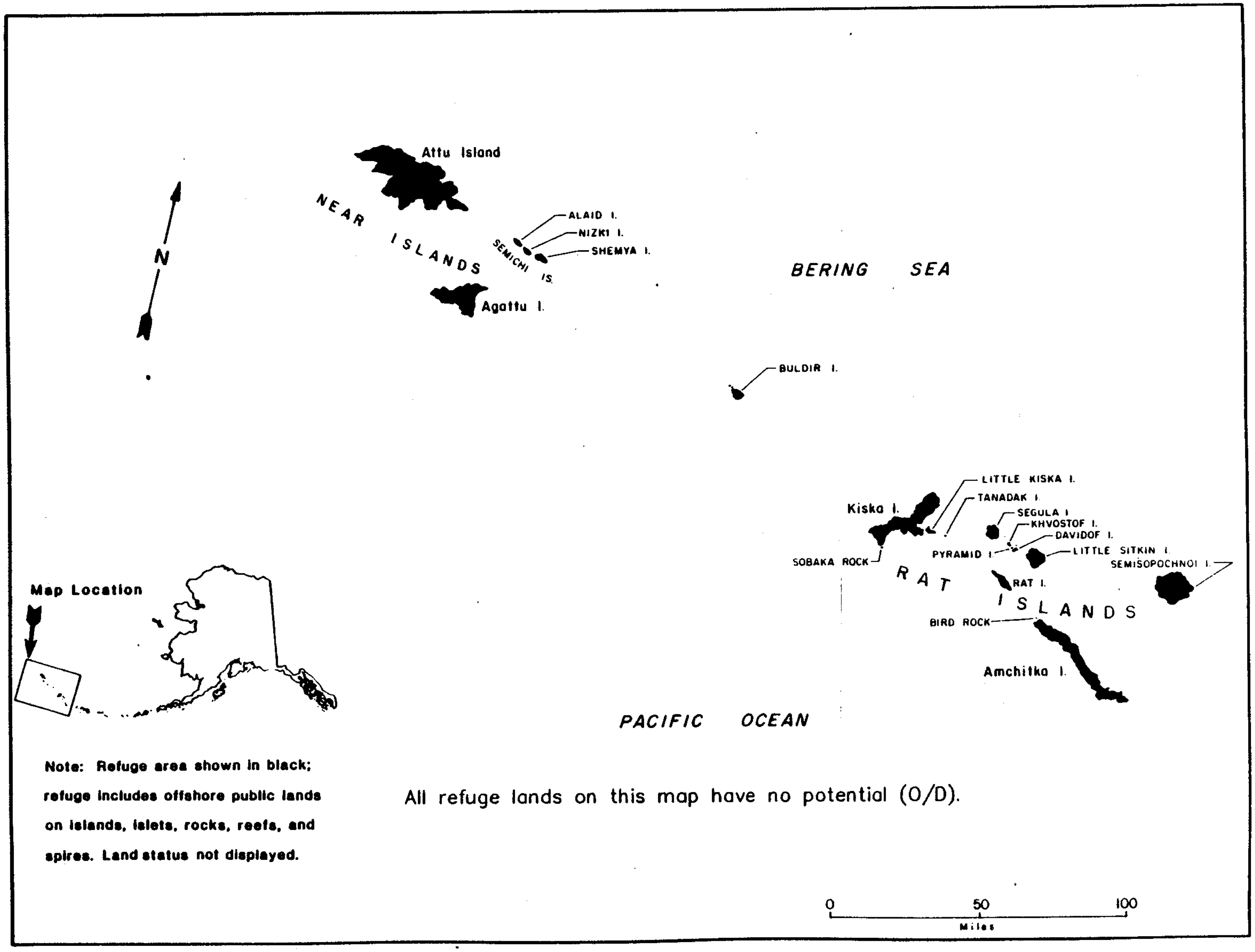


Figure 34. Hydrocarbon occurrence potential in the Aleutian Islands Unit, Near Islands and Rat Islands.

Delarof Islands

The Delarof Islands are located in the Aleutian Islands east of the Rat Islands. This island group includes Amatignak Island, Tanadak Island, Ulak Island, Unalga Island, Dinkum Rocks, Kavalga Island, Gareloi Island, Ogliuga Island, Skagul Island, Tag Island, Ilak Island, and Gramp Rock.

Geology

Fraser and Barnett (1955) and Coats (1955d) mapped the geology of Ulak, Amatiguak, and Gareloi islands. Ulak and Amatiguak islands are comprised almost entirely of volcanic rock or sediments derived from volcanic rock. These two islands do contain some minor intrusive rocks. Gareloi Island is comprised entirely of volcanic rocks. The remainder of the islands in the group probably have geology similar to that of these three islands (Beikman, 1980).

Geochemistry

There is no petroleum geochemistry data for the Delarof Islands. Geochemical data for the areas offshore the Aleutian Islands are encouraging for offshore oil development (Cooper, Scholl, Marlow et al., 1979). Scholl et al., (1976) indicate that summit basins along the Aleutian ridge may be good exploration targets; however, Stewart (1978) states that the sediments near the Aleutian Islands may not make adequate reservoirs.

Hydrocarbon Occurrence Potential

The Delarof Islands have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 35). This classification is based on the overwhelmingly igneous nature of the islands.

Andreanof Islands

The Andreanof Islands are located at approximately the midpoint of the Aleutian chain. They include Tanaga Island, Kanaga Island, Bobrof Island, Ringgold Island, Staten Island, Argonne Island, Dora Island, North Island, South Island, Green Island, Ina Island, Crone Island, Elf Island, Adak Island, Kagalaska Island, Little Tanaga Island, Chisak Island, Umak Island, Aziak Island, Tanaklak Island, Asuksak Island, Kanu Island, Tagadak Island, Great Sitkin Island, Igitkin Island, Anagaksik Island, Ulak Island, Chugul Island, Tagalak Island, Ikiginak Island, Oglodak Island, Kasatochi Island, Koniuji Island, Salt Island, Atka Island, Egg Island, Amila Island, Sagagik Island, Tanadak Island, Agligadak Island, Sequam Island, and an unnamed island north of Elf Island.

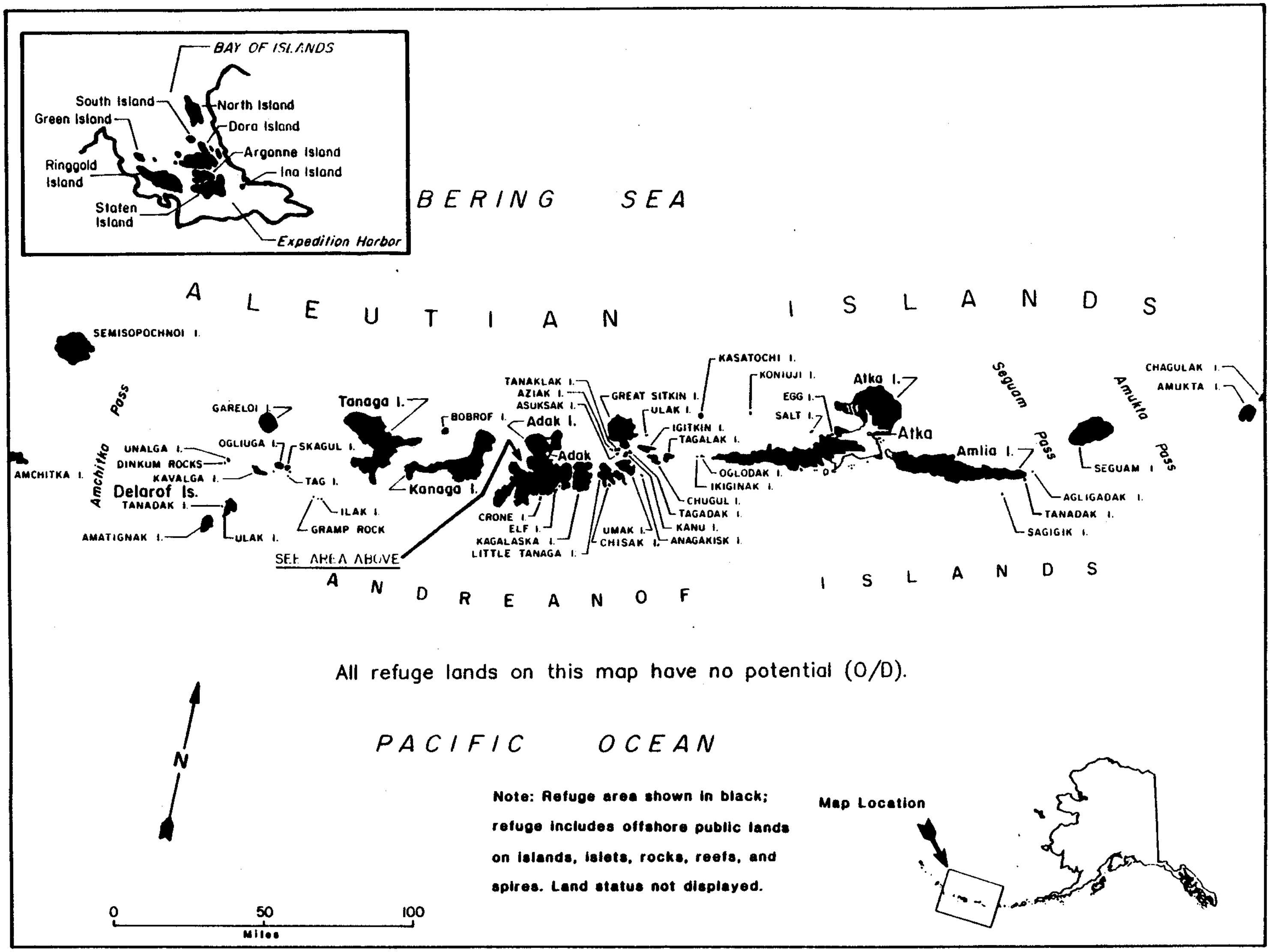


Figure 35. Hydrocarbon occurrence potential in the Aleutian Islands Unit, Delarof Islands and Andreanof Islands.

Geology

Great Sitkin, Adak, Kanaga, Tanaga, Adak, and Kagalaska islands were mapped by Simons and Mathewson (1955), Coats (1955a and 1955b), Fraser and Barnett (1955), Fraser and Snyder (1955), Hein and McLean (1980), and Hein et al., (1984). These islandse all comprise volcanic and intrusive igneous rocks and the sediments derived from them. The remaining islands in the group have similar geology (Beikman, 1980).

Geochemistry

There is no petroleum geochemistry data for the Andreanof Islands. Geochemical data for the areas offshore the Aleutian Islands are encouraging for offshore oil development (Cooper, Scholl, Marlow et al., 1979). Scholl et al., (1976) indicate that summit basins along the Aleutian ridge may be good exploration targets; however, Stewart (1978) states that the sediments near the Aleutian Islands may not make adequate reservoirs.

Hydrocarbon Occurrence Potential

The Andreanof Islands have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 35). This classification is based on the overwhelmingly igneous nature of the islands.

Islands of Four Mountains

The Islands of Four Mountains lie to the east of the Andreanof Islands group. The group contains Amukta Island, Chagulak Island, Yunaska Island, Herbert Island, Carlisle Island, Chuginadak Island, Uliaga Island, and Kagamil Island.

Geology

These islands have not been geologically mapped in detail. Beikman (1980) indicates that they are entirely volcanic in nature.

Geochemistry

There is no petroleum geochemistry data for the Islands of Four Mountains. Geochemical data for the areas offshore the Aleutian Islands are encouraging for offshore oil development (Cooper, Scholl, Marlow et al., 1979). Scholl et al., (1976) indicate that summit basins along the Aleutian ridge may be good exploration targets; however, Stewart (1978) states that the sediments near the Aleutian Islands may not make adequate reservoirs.

Hydrocarbon Occurrence Potential

The Islands of Four Mountains have no hydrocarbon occurrence potential, a BLM mineral potential classification of 0/D (figure 36). This classification is based on the overwhelmingly igneous nature of the islands.

Fox Islands

The Fox Islands lie near the eastern end of the Aleutian Island chain. The Fox Islands include Samalga Island, Adugak Island, Umnak Island, Vsevidof Island, Kigul Island, Ogchul Island, Pustoi Island, Emerald Island, Bogoslof Island, Fire Island, Unalaska Island, the Baby Islands, Wislow Island, Round Island, Dushkot Island, Peter Island, Buck Island, Ogangen Island, Sedanda Island, Egg Island, Unalga Island, and the islets in Tanaskan Bay, Erskine Bay, and Kisselen Bay.

Geology

Umnak, Bogoslof, Fire and Unalaska islands have been geologically mapped by Beyers (1955), Drewes et al., (1955), and Lankford and Hill (1979). Umnak and Unalaska islands are comprised entirely of volcanic or intrusive igneous rocks and sediments derived from them. Bogoslof and Fire islands are comprised entirely of volcanic rocks erupted since 1795. The remaining islands in the group have geology that is similar to Umnak and Unalaska islands.

Geochemistry

There is no petroleum geochemistry data for the Fox Islands. Geochemical data for the areas offshore the Aleutian ing for offshore oil development (Cooper, Scholl, Marlow et al., 1979). Scholl et al., (1976) indicate that summit basins along the Aleutian ridge may be good exploration targets; however, Stewart (1978) states that the sediments near the Aleutian Islands may not make adequate reservoirs.

Hydrocarbon Occurrence Potential

The Fox Islands have no hydrocarbon occurrence potential, a BLM mineral potential classification of 0/D (figure 36). This classification is based on the overwhelmingly igneous nature of the islands.

Krenitzin Islands

The Krenitzin Islands are the eastern most island group in the Aleutian chain. Only Unimak Island lies between the Krenitzin Islands and the end of the Alaska Peninsula. The Krenitzin Islands include Akutan Island, Akun Island, Avatanak Island, Tigalda Island, Kaligagan Island, Aiktak Island, Ugamak Island, and Round Island.

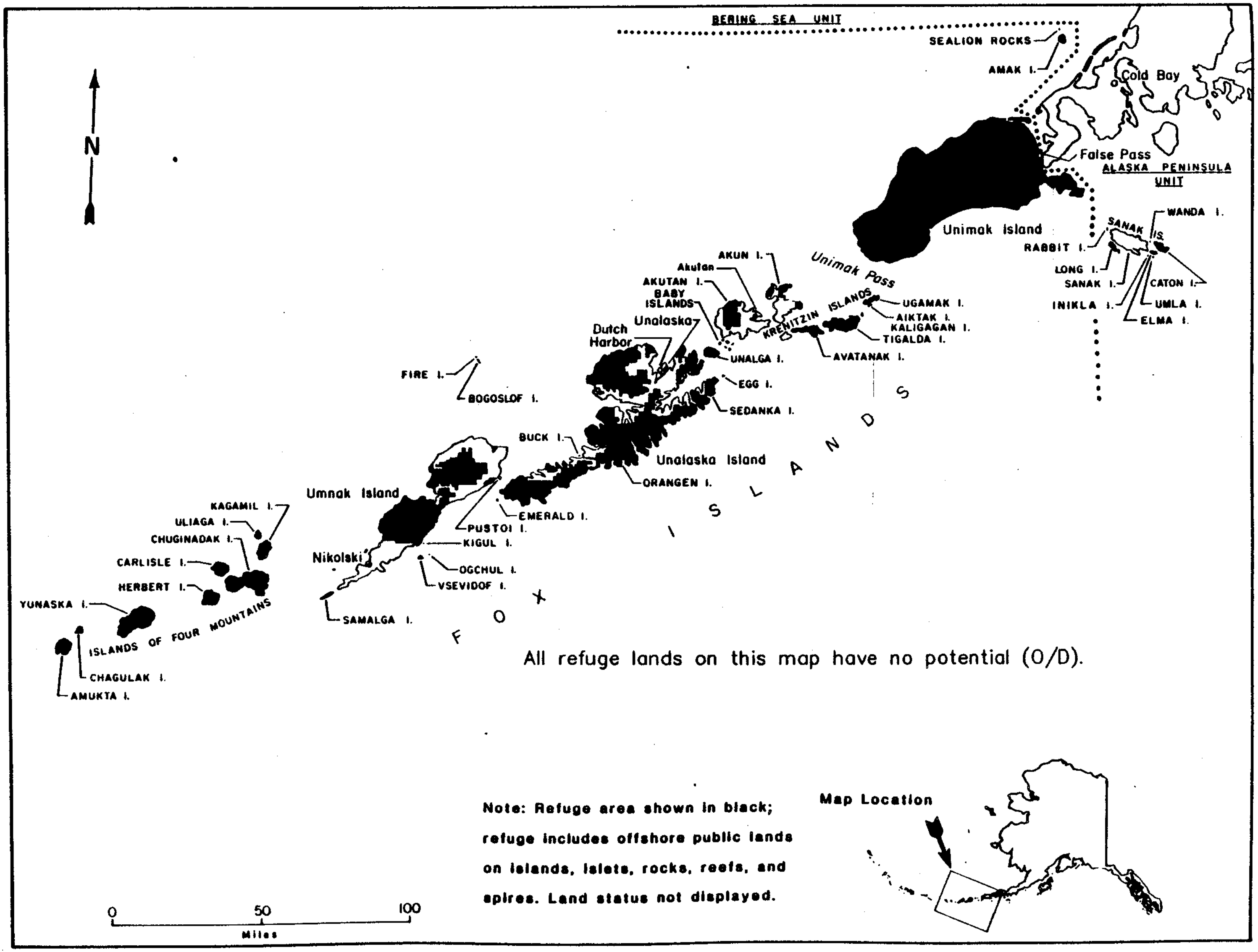


Figure 36. Hydrocarbon occurrence potential in the Aleutian Islands Unit, the Islands of Four Mountains to Sealion Rocks.

Geology

The Krenitzin Islands are comprised of volcanic rocks and sedimentary rocks derived from the volcanic rocks (Beikman, 1980).

Geochemistry

There is no petroleum geochemistry data for the Krenitzin Islands. Geochemical data for the areas offshore the Aleutian Islands are encouraging for offshore oil development (Cooper, Scholl, Marlow et al., 1979). Scholl et al., (1976) indicate that summit basins along the Aleutian ridge may be good exploration targets; however, Stewart (1978) states that the sediments near the Aleutian Islands may not make adequate reservoirs.

Hydrocarbon Occurrence Potential

The Krenitzin Islands have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 36). This classification is based on the overwhelmingly igneous nature of the islands.

Amak Island and Sealion Rocks

Amak Island and Sealion Rocks lie north of the end of the Alaska Peninsula.

Geology

Amak Island and Sealion Rocks comprise volcanic rocks (Burk, 1965, and Beikman, 1980).

Geochemistry

There is no petroleum geochemistry data for the Amak Island and Sealion Rocks. Geochemical data for the areas offshore the Aleutian Islands are encouraging for offshore oil development (Cooper, Scholl, Marlow et al., 1979).

Hydrocarbon Occurrence Potential

Amak Island and Sealion Rocks have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 36). This classification is based on the overwhelmingly igneous nature of the islands.

Unimak Island

Unimak Island is the eastern most of the Aleutian Islands, lying just west of the tip of the Alaska Peninsula.

Geology

Unimak Island comprise volcanic rock, except for the northeastern corner of the island (Beikman, 1980). Mclean (1979a) indicates that the Quaternary sediments on the northeastern corner of the island probably covers more volcanic rocks.

Geochemistry

There is no petroleum geochemistry data for Unimak Island. Geochemical data for the areas offshore the Aleutian Islands are encouraging for offshore oil development (Cooper, Scholl, Marlow <u>et al</u>., 1979). Scholl <u>et al</u>. (1976) indicate that summit basins along the Aleutian ridge may be good exploration targets; however, Stewart (1978) states that the sediments near the Aleutian Islands may not make adequate reservoirs.

Hydrocarbon Occurrence Potential

Unimak Island has no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 36). This classification is based on the overwhelmingly igneous nature of the island.

Alaska Peninsula Unit

<u>Sankin Island</u>

Sankin Island lies at the western end of the Alaska Peninsula in Sankin Bay.

Geology

Sankin Island has not been mapped geologically; however, as the Tertiary (Miocene or Pliocene, 24 Ma to 1.6 Ma) Tachilni Formation forms the shoreline around Sankin Bay, Sankin Island is probably also underlain by Tachilni Formation rocks. The Tachilni Formation is comprised of nonmarine sandstone, mudstone, conglomerate, and minor volcanic breccia interfingered with fossiliferous sandstone and conglomerate (McLean, 1979a and 1979b). Most of these sediments had volcanic sources.

Geochemistry

McLean (1979b) reports that the rocks of the Cold Bay-False Pass area contain predominantly woody kerogen, which is gas prone, and that rocks rich in organic carbon are rare.

Hydrocarbon Occurrence Potential

Sankin Island has a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/A. This classification is based on the volcanic nature of the Tachilni Formation sediments, and the poor source rock characteristics of all the sedimentary rocks in the area as based on geochemistry. Bascle et al., (1987) gave the adjacent portions of the Alaska Peninsula a low hydrocarbon occurrence potential (L/A).

Sanak Islands

The Sanak Islands lie southeast of Unimak Island. Those islands of the Sanak Island that are within the refuge include Long Island, Rabbit Island, Wanda Island, Elma Island, Inikla Island, Umla Island, Caton Island, and several other islets and rocks.

Geology

The Sanak Islands are underlain by the Cretaceous (144 Ma to 66 Ma) Shumagin Formation which has been intruded by a granodiorite of Tertiary age (66 Ma to 1.2 Ma). These older rocks are overlain by a thin veneer of Quaternary (younger than 1.2 Ma) sediments. The Shumagin Formation consists of interbedded flysch deposits of turbiditic sandstone, siltstone, and shale and conglomerate and breccia. The Shumagin Formation has been complexly deformed and metamorphosed. It is the equivalent of the Kodiak Formation on Kodiak Island. (Burk, 1965).

Geochemistry

Von Huene, Fisher et al., (1980) state that the vitrinite-reflectance values for the Kodiak Formation are 3.5 to 4.0. As the Shumagin Formation is the equivalent of the Kodiak formation, vitrinite-reflectance values of 3.5 to 4.0 are probably valid for it. These vitrinite-reflectance values would imply that there is no organic material remaining in the rocks capable of generating either oil or gas, and that any oil or gas that had previously been generated would have been degraded or driven off.

Hydrocarbon Occurrence Potential

The Sanak Islands have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 37). This classification is based on the metamorphic and igneous nature of the rocks underlying the Sanak Islands.

Egg and Amagat Islands to Omega, Kennoys, and Jude Islands

The part of the Alaska Peninsula Unit from Egg and Amagat islands to Omega, Kennoys, and Jude Islands lies between the Sanak Islands and the Shumagin Islands. This area includes Egg Island, Amagat Island, the Sandman

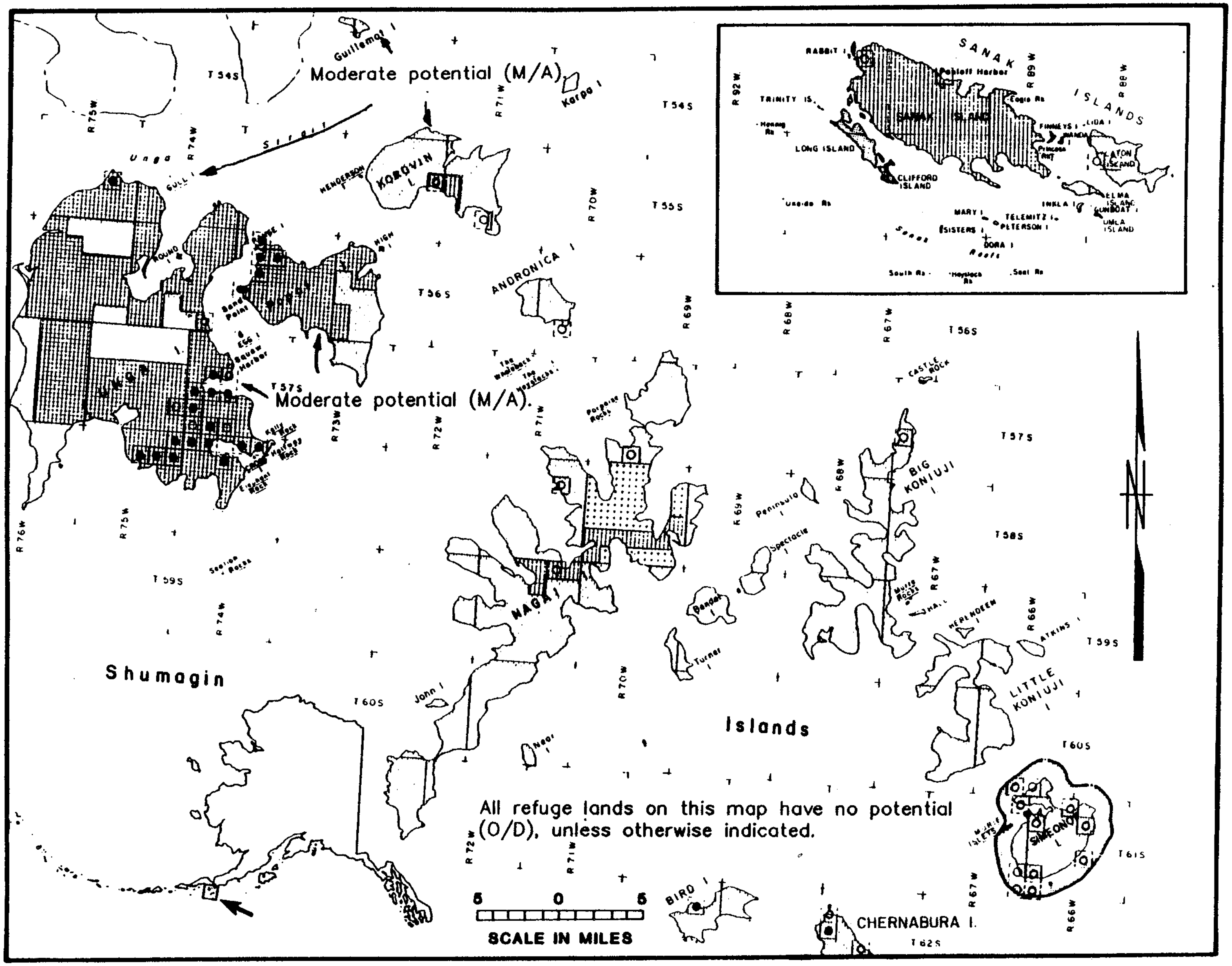


Figure 37. Hydrocarbon occurrence potential in the Alaska Peninsula Unit, Sanak Islands to the Shumagin Islands.

Reefs, Sozavarika Island, Buyan Island, Patton Island, Sarana Island, Rona Island, Fox Island, the Pavlof Islands, Omega Island, Kennoys Island, and Jude Island. The Sandman Reefs include Goose Island, Little Goose Island, Midun Island, High Island, Shushilnoi Island, Hunt Island, Umga Island, and various other islets and rocks; and the Pavlof Islands include Inner Iliasik Island, Outer Iliasik Island, Goloi Island, Dolgoi Island, Poperechnoi Island, Ukolnoi Island, Wosnesenski Island, and The Pinnacle.

Geology

The geology of this area is very similar to that of the adjacent Alaska Peninsula which was discussed in the Alaska Peninsula/Becharof National Wildlife Refuges Oil and Gas Assessemnt (Bascle *et al*., 1987).

Geochemistry

The geochemistry of this area is very similar to that of the adjacent Alaska Peninsula which was discussed in the Alaska Peninsula/Becharof National Wildlife Refuges Oil and Gas Assessemnt (Bascle *et al*., 1987).

Hydrocarbon Occurrence Potential

The northern edge of Deer Island, the north half of Inner Iliasik Island, Goloi Island, and Dolgoi Island have a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/A (figure 38). The remainder of the area has no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 38). These classifications are based on the geology as discussed in Burk (1965) and Bascle *et al*., (1987) and the geochemistry as discussed by Bascle *et al*.

Shumagin Islands

The Shumagin Islands lie to the southeast of the Alaska Peninsula between Coal Bay and the Kupreanof Peninsula. Unga Islands, Gull Islands, Egg Islands, Popof Islands, Henderson Islands, Korovin Islands, Guillemot Islands, Karpa Islands, Andronica Islands, Nagai Islands, John Islands, Near Islands, Twin Islands, Turner Islands, Bendel Islands, Spectacle Islands, Peninsula Islands, Big Koniuji Islands, Hall Islands, Herendeen Islands, Litle Koniuji Islands, Atkins Islands, Bird Islands, Chernabura Islands, Simeonof Islands, Castle Rock, Murre Rocks, The Whaleback, The Haystacks, and other unnamed islets are included in the Shumagin Islands.

Geology

The Shumagin Islands are divided into two distinct areas by the geology of the area. The first area has a geology similar to that of the Alaska Peninsula and consist of the islands northwest of the West Nagai Strait (Unga, Gull, Egg, Popof, Henderson, Korovin, Guillemot, Karpa, and Andronica islands,

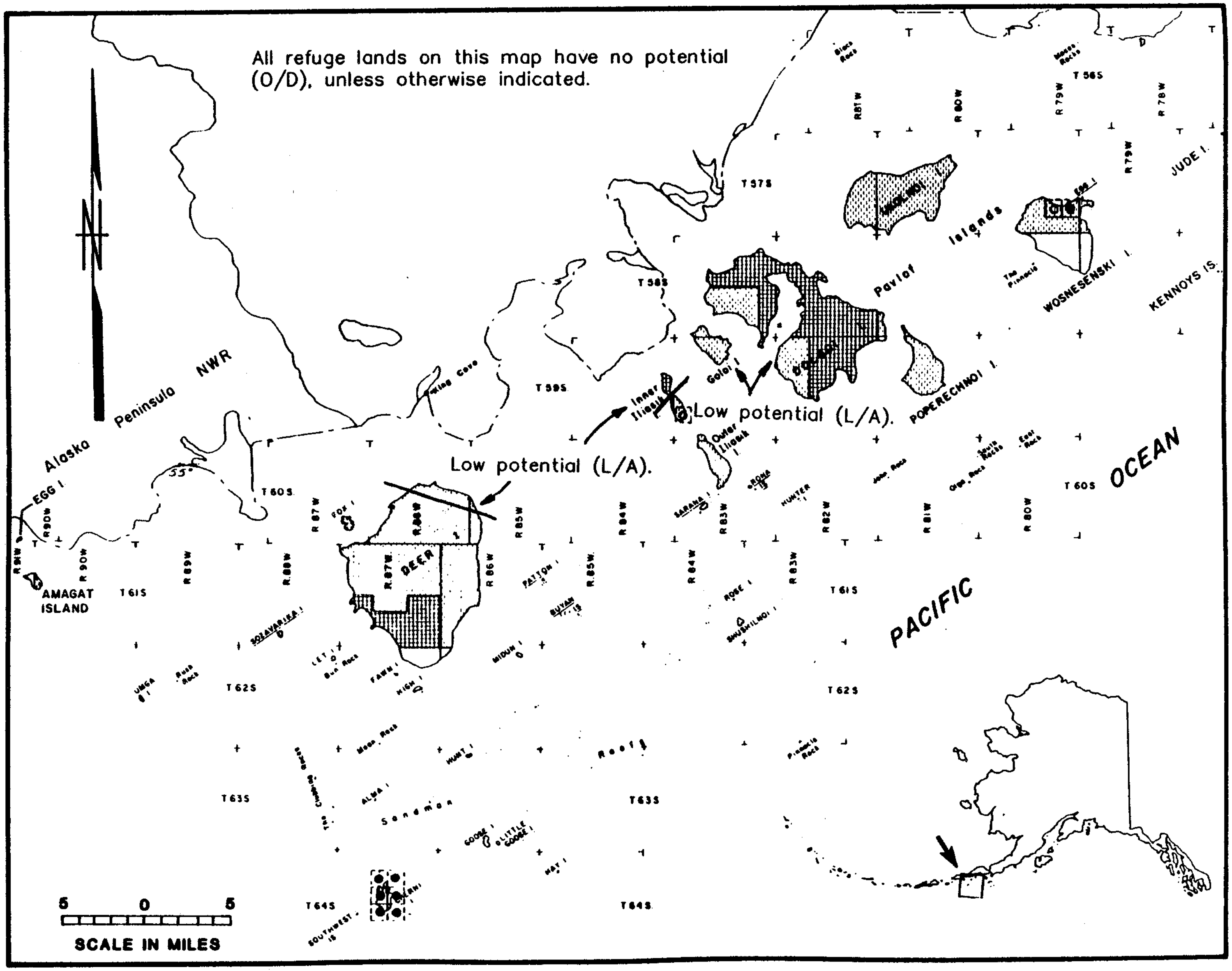


Figure 38. Hydrocarbon occurrence potential in the Alaska Peninsula Unit, Egg Island to Jude Island.

The Whaleback, and The Haystacks). The remainder of the area has geology similar to Kodiak Island or the Sanak Islands. See the Alaska Peninsula/ Becharof National Wildlife Refuges Oil and Gas Assessment (Bascle et al., 1987) for a detailed discussion of the geology of the islands with geology like that of the Alaska Peninsula, and the Kodiak National Wildlife Refuge Oil and Gas Assessment (Bascle, 1988) for a detailed description of the geology for remainder of the islands in the group.

Geochemistry

The geochemistry of the Shumagin Islands is directly related to the geology of the two areas. See the appropriate reference for detailed discussions of the geochemistry of the Shumagin Islands.

Hydrocarbon Occurrence Potential

Unga, Gull, Popof, Henderson, Korovin, and Guillemot islands have a moderate hydorcarbon occurrence potential, a BLM mineral potential classification of M/A (figure 37). The remainder of the islands in the Shumagin Islands group have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 37). The classifications are based on the discussions of geology and geochemistry found in Bascle et al., (1987) and Bascle (1988).

Chiachi Islands to Alinchak Bay

The portion of the Alaska Peninsula Unit between the Chiachi Islands and Alinchak Bay is the northwestern end of the unit. This area includes the Chiachi Islands, the Brother Islands, Spitz Island, Mitrofania Island, Seal Cape, Chankliut Island, Gull Island, Nakchamik Island, Kak Island, Atkulik Island, the Unavikshak Islands, Kumlik Island, Garden Island, Eagle Island, Sutwik Island, Hydra Island, Long Island, Central Island, Ugaiushak Island, the Semidi Islands, Derickson Isa, the Aiugnak Columns, David Island, Poltava Island, Navy Island, Ashiiak Island, the Kilokak Rocks, the Wide Bay Islands, Jute Island, Chirikof Island, Nagai Rocks, islets in Chiginagak, Agripina, and Alinchak bays, Kekernoi Islets, and several unnamed islands south of Cape Kumlik. The Chiachi Islands include Leader Island, Jacob Island, Paul Island, Chiachi Island, Petrel Island, Shapka Island, Pinusuk Island, and several islets near Chiachi Island. The Semidi Islands include Aghiyuk Island, Chowiet Island, several unnamed islands and islets, and surrounding submerged lands. The Wide Bay Islands include Titcliffe Island, Hartman Island, Terrace Island, West Channel Island, East Channel Island, and several unnamed islands.

Geology

This area, except the Semidi Islands, Chirikof Island, and the Nagai Rocks, has geology similar to the adjacent Alaska Peninsula. The Semidi Islands are underlain by intrusive igneous rocks, and Chirikof Island and the

Nagai Rocks are underlain by the Sitkinak and Sitkalidak formations as found on Kodiak Island. For a detailed description of the geology of this area see the appropriate refuge oil and gas assessment (Bascle et al., 1987 and Bascle, 1988).

Geochemistry

See the Alaska Peninsula/Becharof and Kodiak National Wildlife Refuge oil and gas assessments for detailed descriptions of the geochemistry of this area.

Hydrocarbon Occurrence Potential

Shapaka Island, Spitz Island, Nakchamik Island, Kak Island, Atkulik Island, and the Semidi Islands have no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figures 39 and 40). Chirikof Island and the Nagai Rocks have a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/A. Leader Island, Paul Island, and Jacob Island have a moderate hydrocarbon occurrence potential, a BLM mineral potential classification of M/A (figure 39). The remainder of the islands in this area have a high hydrocarbon occurrence potential, a BLM mineral potential classification of H/C (figures 39, 40, and 41). The classification for the Semidi Islands is based on the igneous nature of the rocks forming the islands as indicated by Burk (1965). The classifications for the remainder of area are based on the geology and geochemistry discussed in the two references mentioned under geology and geochemistry.

Gulf of Alaska Unit

Islands and Lands Associated with Kodiak and Afognak Islands

The islands and lands associated with Kodiak and Afognak islands is comprised of smaller islands and submerged lands around the larger islands. They include Sundstrom Island, Aiktalik Island, the Geese Islands, Akhiok Island, Flat Island, Sitkalidak Island, Fox Island, Bear Island (Kodiak), Harvester Island, Noisy Island, Sally Island, Sheep Island, Village Island, Green Island, Mary Island, Viesoki Island, Zaimba Island, Puffin Island, Grassy Island, Alligator Island, Rocky Island, Teck Island, Hogg Island, Bear Island (Afognak), Delphin Island, Discoverer Island, Murphy Island, the Sealion Rocks, Sea Otter Island, the Latex Rocks, Dark Island, several unnamed islands around Noisy Island, several unnamed islets at the head of Northeast Arm, several unnamed islets around Green Island, and the submerged lands, tidelands, and water column in Womens Bay, around Afognak Island, and in the Karluk area from Wolcott Reef to Sturgeon Lagoon.

Geology

The geology of this area is discussed in detail in the Kodiak National Wildlife Refuge Oil and Gas Assessment (Bascle, 1988).

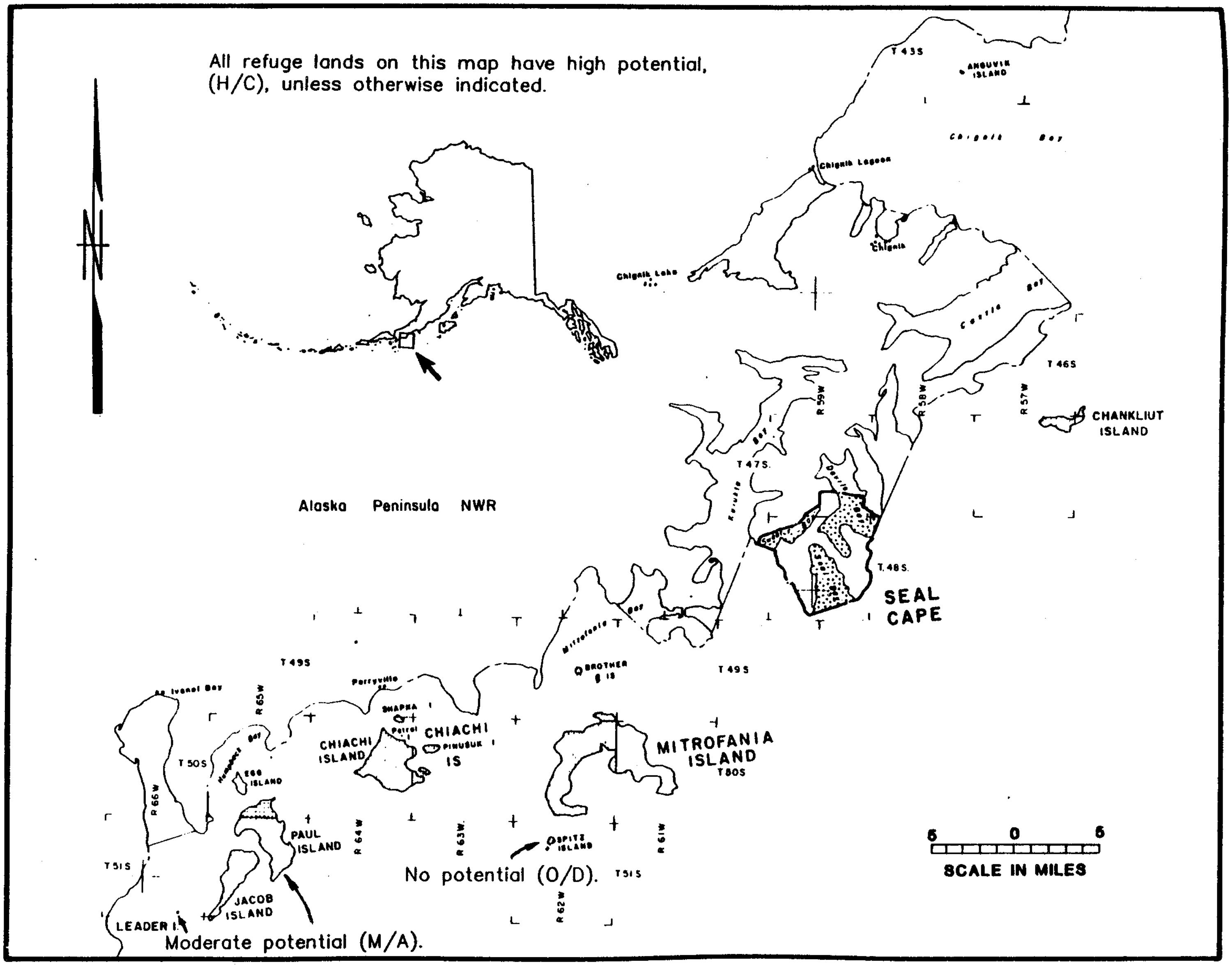


Figure 39. Hydrocarbon occurrence potential in the Alaska Peninsula, Leader Island to Anguvik Island.

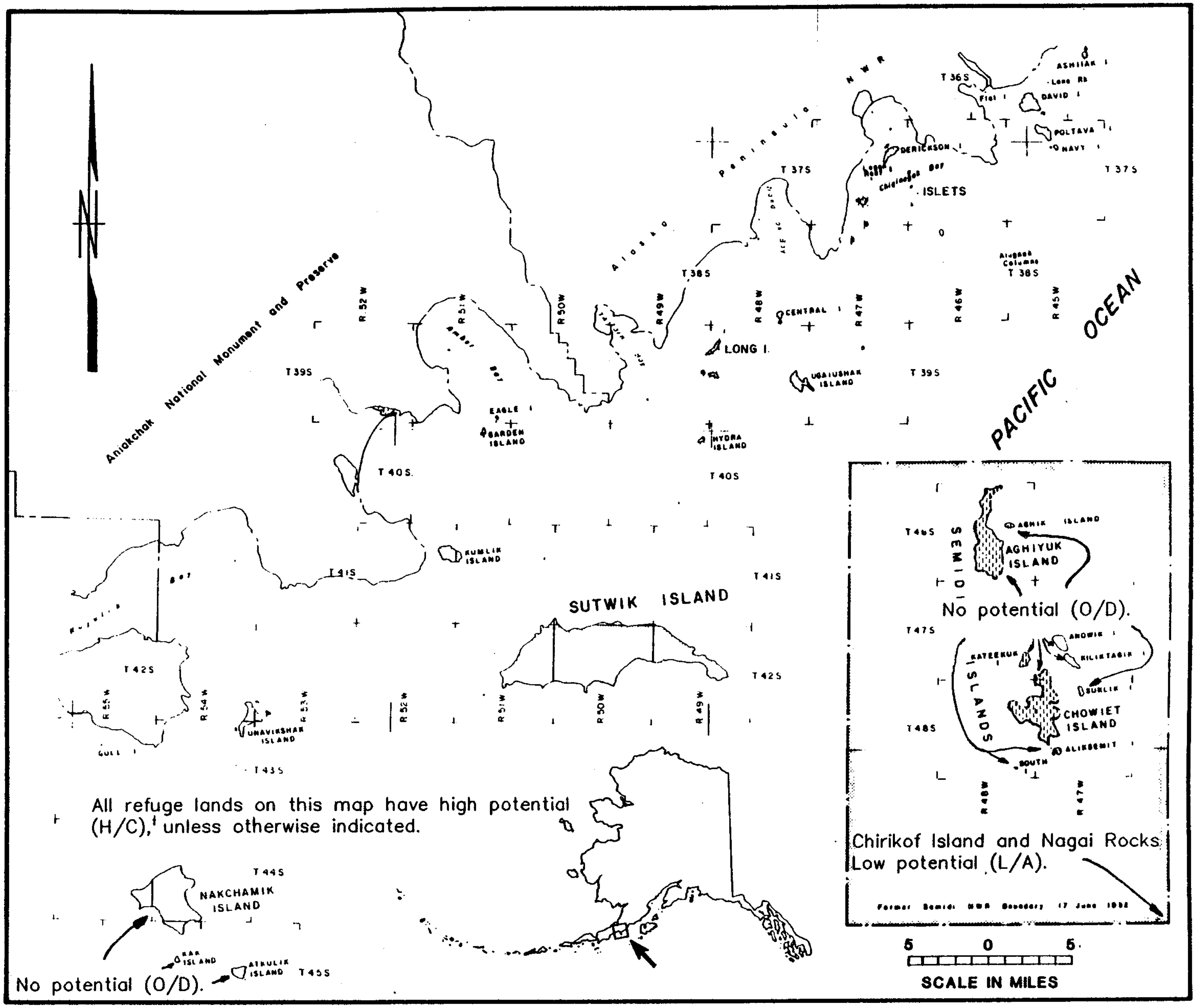


Figure 40. Hydrocarbon occurrence potential in the Aleutian Islands Unit, Gull Island to Ashiiak Island and the Semidi Islands.

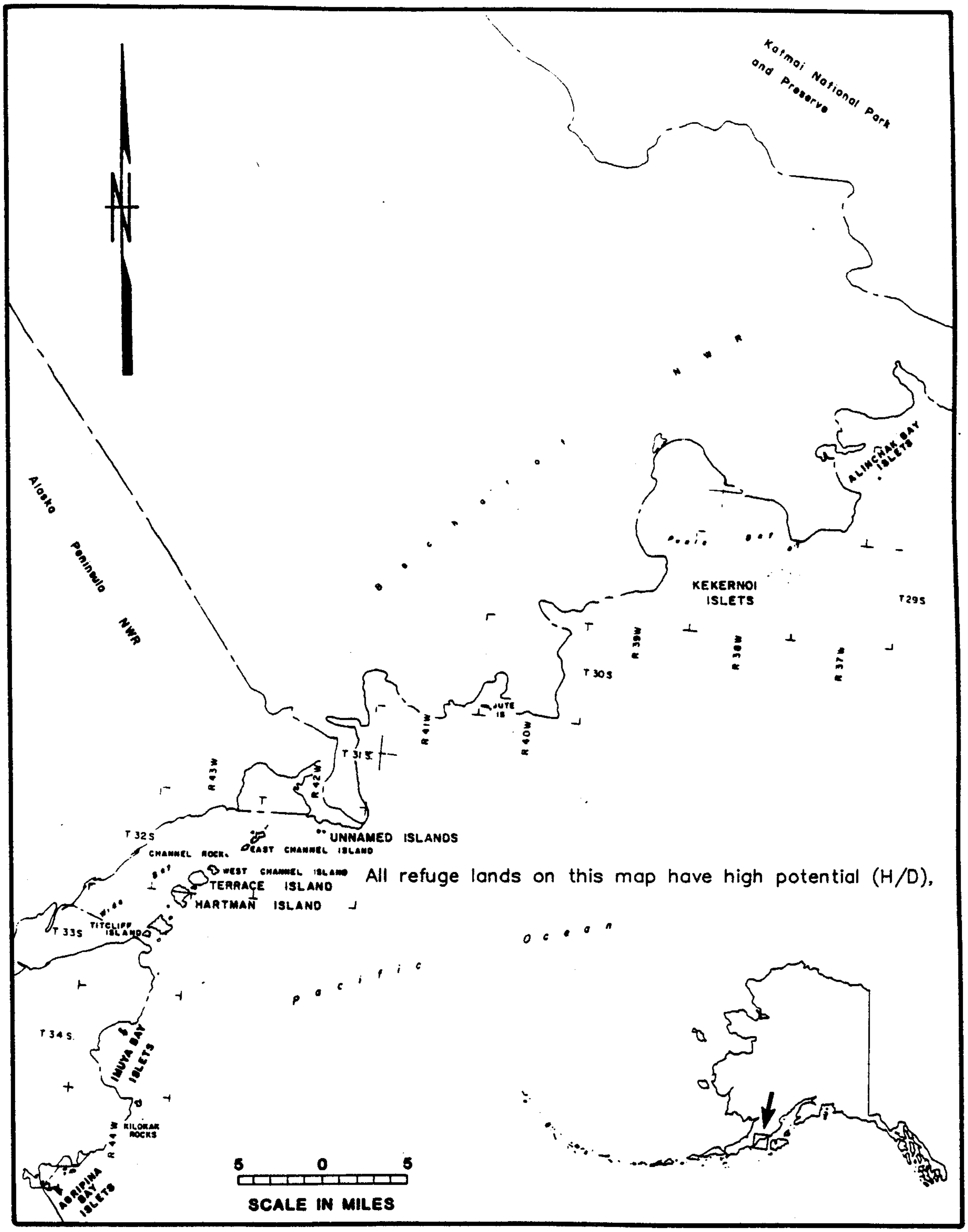


Figure 41. Hydrocarbon occurrence potential in the Alaska Peninsula Unit, Agripina Bay to Alinchuk Bay.

Geochemistry

The geochemistry of this area is discussed in detail in the Kodiak NWR Oil and Gas Assessment (Bascle, 1988).

Hydrocarbon Occurrence Potential

The Geese Islands, Flat Island, that portion of Sitkalidak Island southeast of a line drawn between the southeastern shores of McDonald Lagoon and Rolling Bay, and that portion of Aiktalik Island southeast of a line drawn along the shoreline of Aiktalik Cove have a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/A (figure 42). The remainder of the area has no hydrocarbon occurrence potential, a BLM potential classification of O/D (figures 42, 43, 44, 45, and 46). These classifications are based on the geology and geochemistry as discussed by Bascle (1988).

Islands and Rocks in Cook Inlet

The islands and rocks in Cook Inlet include Bruin Island, the Mushroom Islets, White Gull Island, Turtle Reef, Iniskin Rock, Vert Island, Scott Island, Iniskin Island, Pomeroy Island, Big Rock, Oil Reef, Gull Island, Duck Island, Chisik Island, and Sixty Foot Rock.

Geology

The stratigraphy of the islands and rocks in Cook Inlet was discussed in detail in the Kenai NWR Oil and Gas Assessment (Teseneer, et al., 1987). Bruin Island is underlain by igneous rocks, possibly diorite. Chisik Island is underlain by the Chinitna and Naknek Formations. The Mushroom Islets, Vert Island, Scott Island, Iniskin Island, Pomeroy Island, Gull Island, and Duck Island are all underlain by the Naknek Formation. White Gull Island, Turtle Reef, Oil Reef, Iniskin Rock, Big Rock, and Sixty Foot Rock are all unmapped; however, all of them, except for White Gull Island and Sixty Foot Rock, are probably underlain by the Naknek Formation. White Gull Island is underlain by either igneous rocks or the Triassic (245 Ma to 208 Ma) Bruin Bay limestone (Magoon, Adkison, and Egbert, 1976). The Bruin Bay limestone is similar to the Triassic limestone, and chert and greenstone units that occur south of Kachemak Bay near the end of the Kenai Peninsula that were discussed in Teseneer et al., (1987). Sixty Foot Rock is probably underlain by the Triassic chert and greenstone unit mentioned above.

Geochemistry

The geochemistry of these rocks is discussed in detail in the Kenai NWR Oil and Gas Assessment.

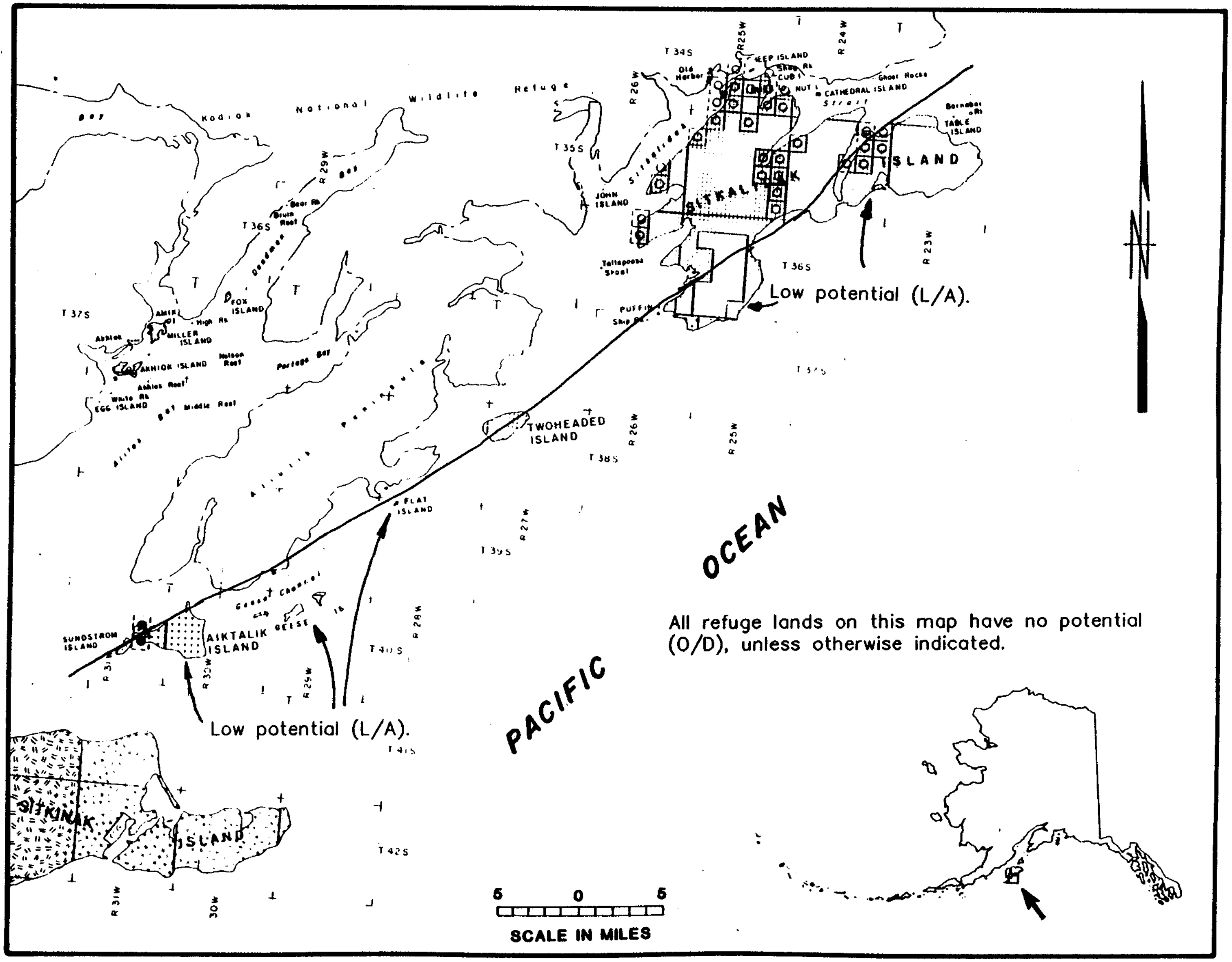


Figure 42. Hydrocarbon occurrence potential in the Alaska Peninsula Unit, Sitkinuk Island to Ghost Rocks.

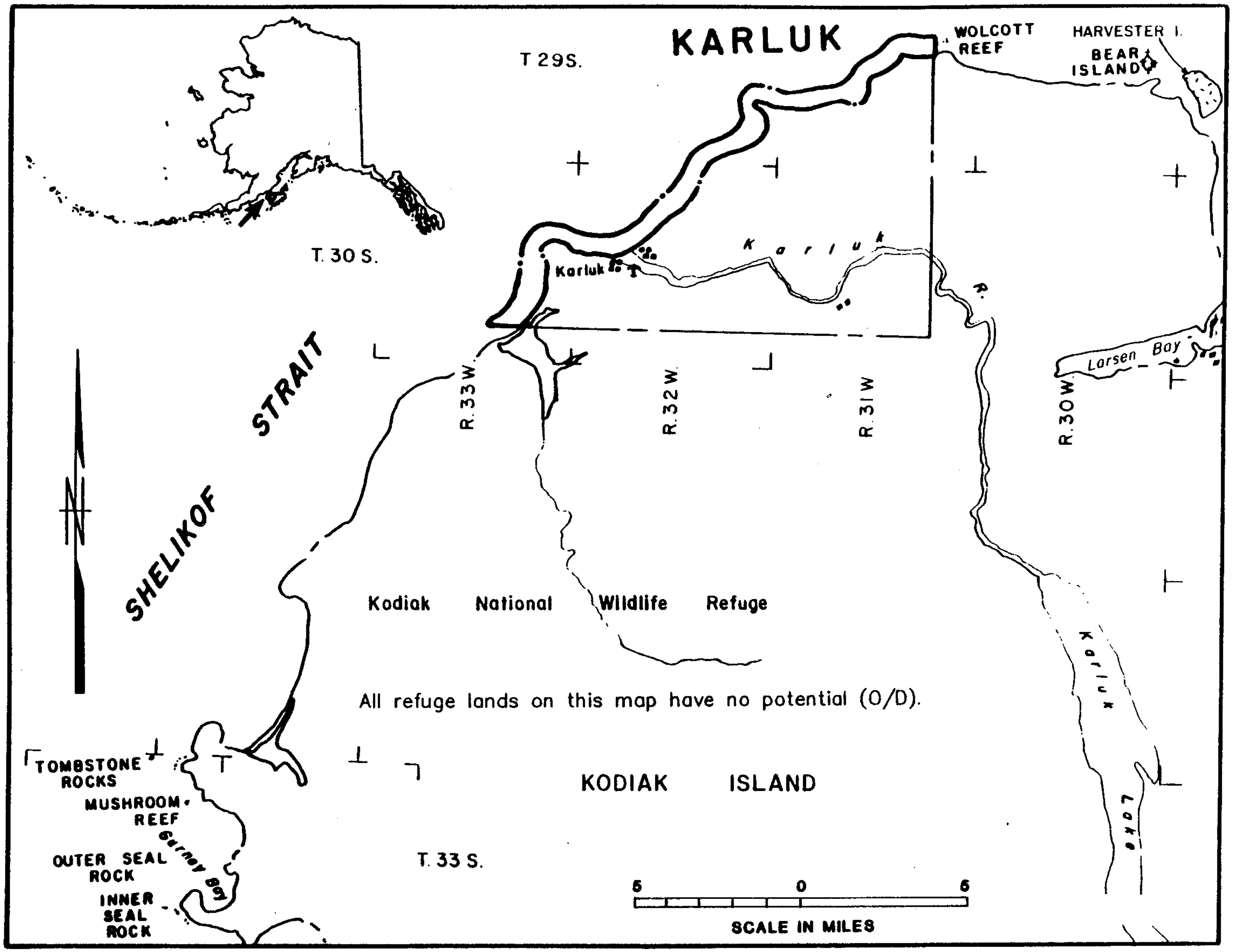


Figure 43. Hydrocarbon occurrence potential in the Alaska Peninsula Unit, Inner Seal Rock to Larsen Bay.

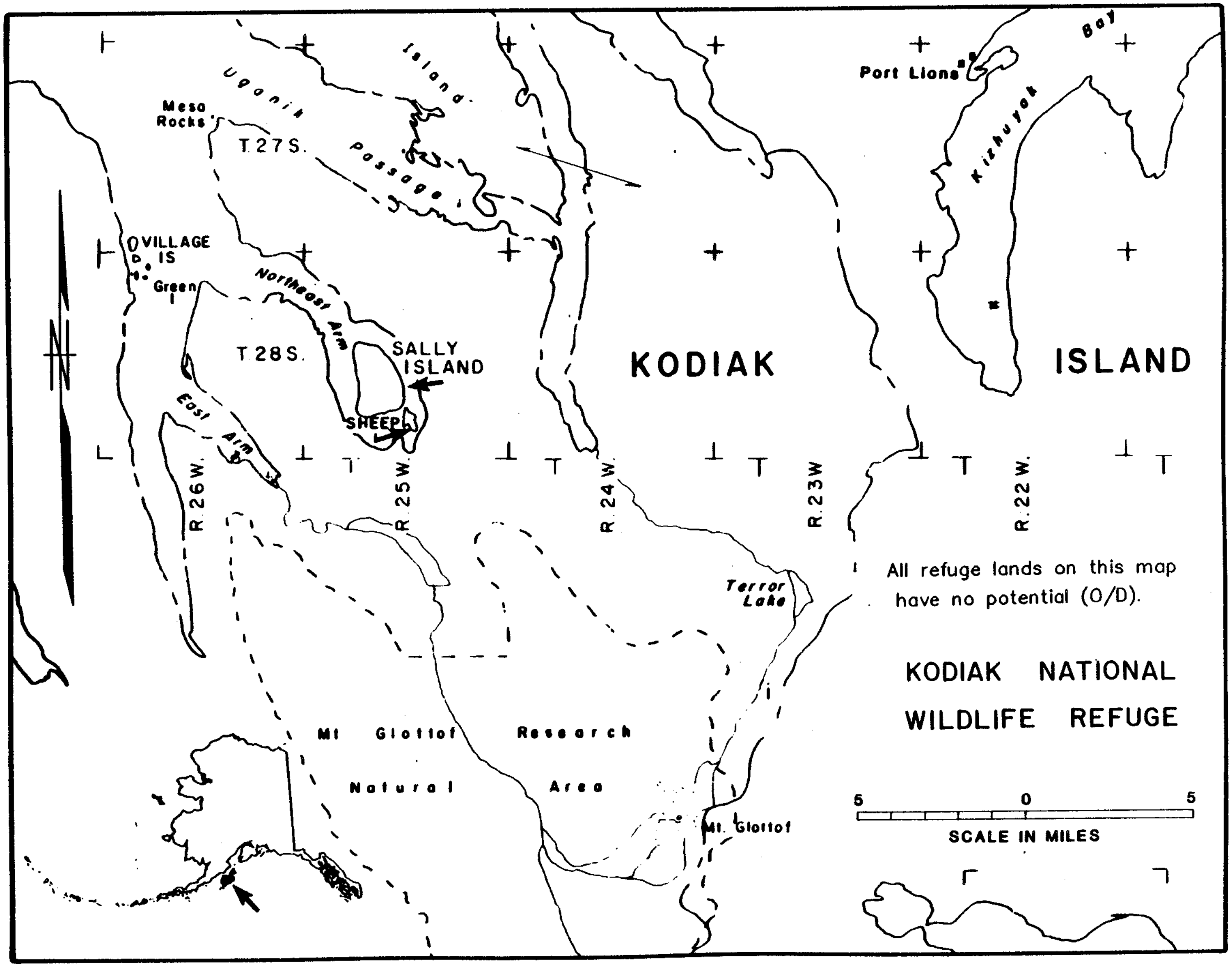


Figure 44. Hydrocarbon occurrence potential of the Alaska Peninsula Unit, Village Island to Kizhuyak Bay.

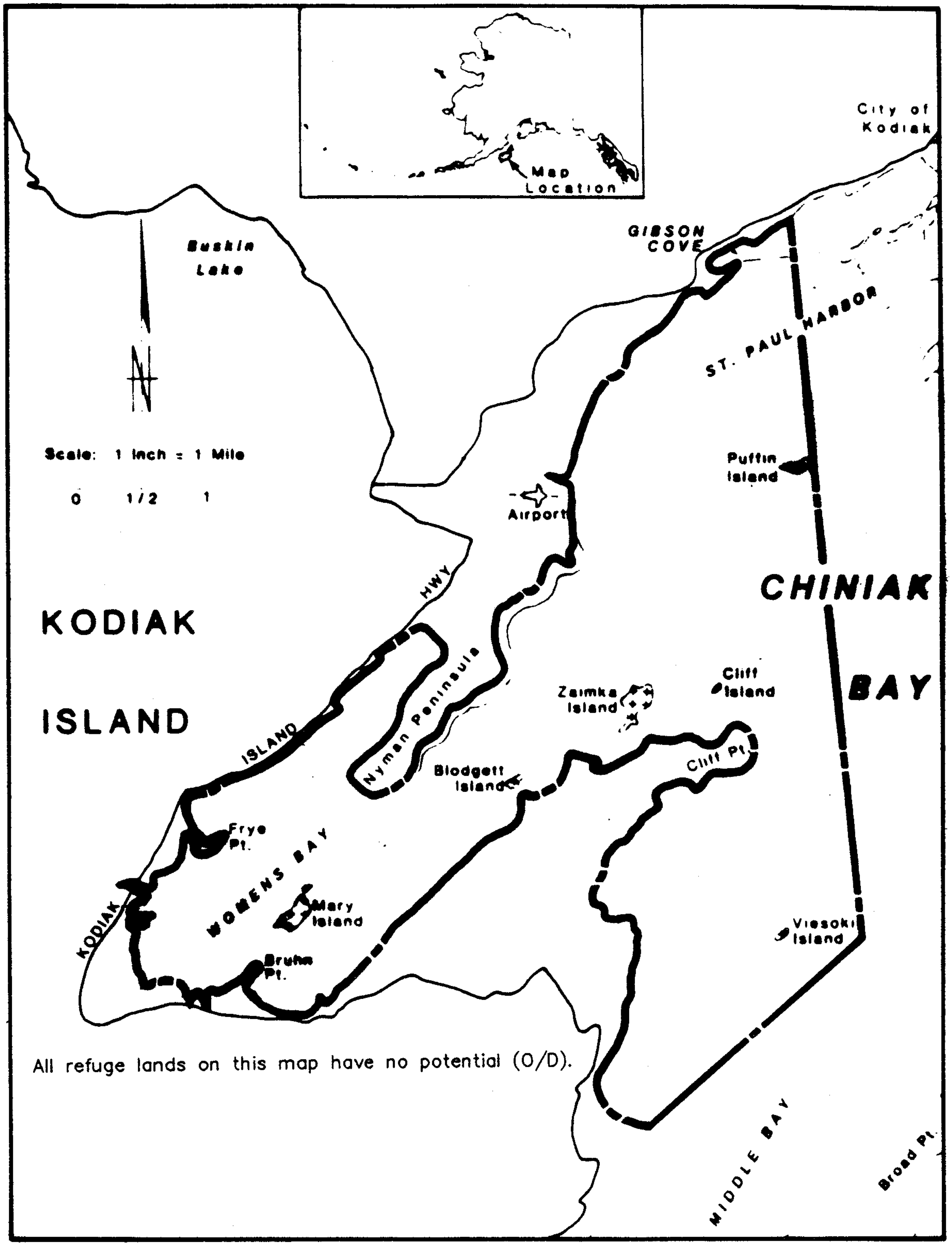


Figure 45. Hydrocarbon occurrence potential in the Alaska Peninsula Unit, Womens Bay.

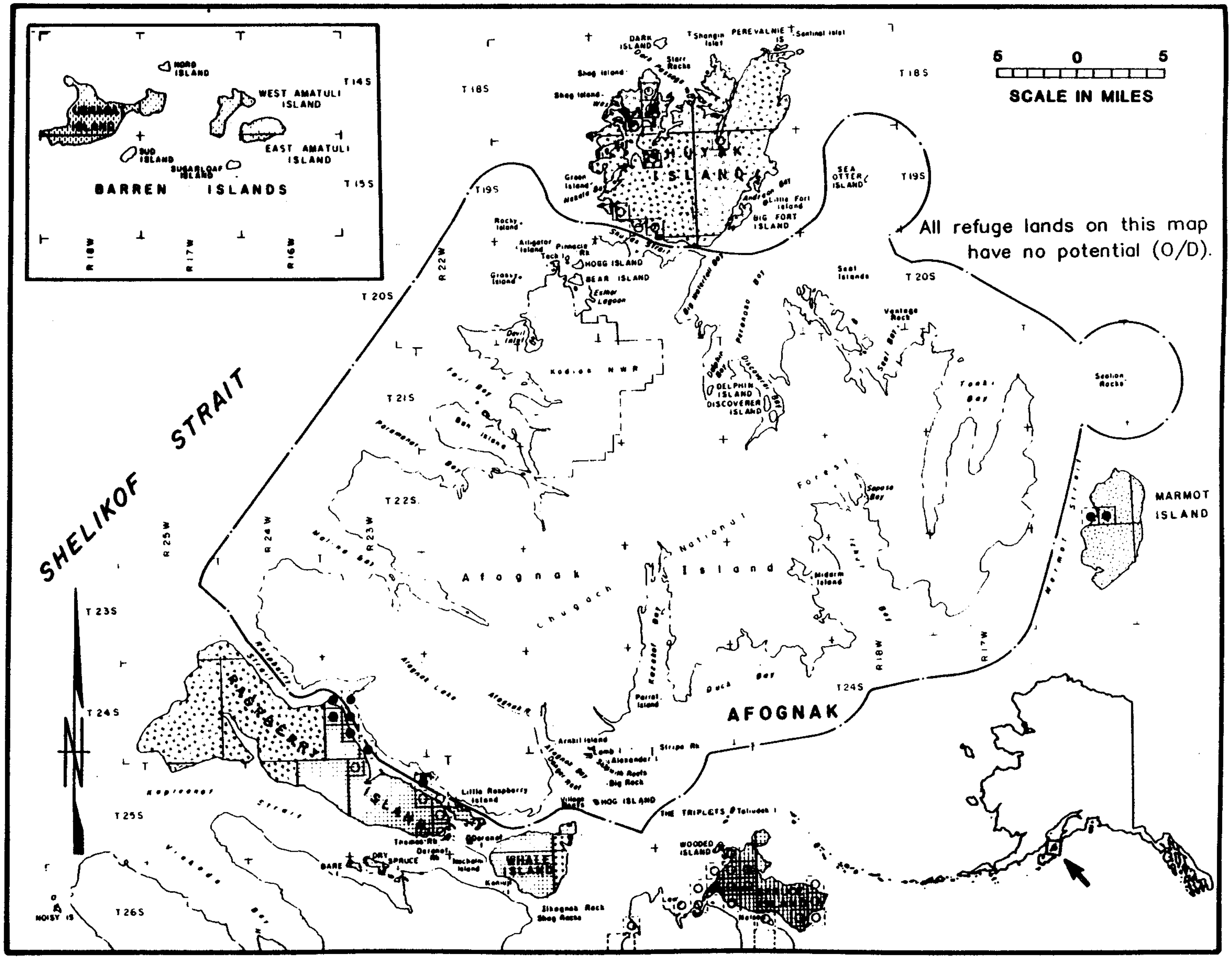


Figure 46. Hydrocarbon occurrence potential in the Alaska Peninsula Unit, Wooded Island to the Barren Islands.

Hydrocarbon Occurrence Potential

Bruin Island has no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 41). This classification is based on the igneous nature of the rocks composing the island.

Sixty Foot Rock and White Gull Island have a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/A (figures 47 and 48). This classification is based on the probable nature of the rocks underlying them. These rocks are slightly metamorphosed or igneous in nature and would have no potential; however, there is a possibility of these islands being underlain by other rocks that have some potential.

The remainder of the area has a high hydrocarbon occurrence potential, a BLM mineral potential classification of H/B (figure 47). This classification is based on the geology and geochemistry discussed in the Kenai NWR Oil and Gas Assessment.

Barren Islands and Chugach Islands

The Barren and Chugach Islands lie at the end of the Kenai Peninsula, with the Chugach Islands just offshore, and the Barren Islands approximately 15 miles to the southwest. The Barren Islands include Carl Island, Ushagat Island, Sugarloaf Island, Sud Island, Nord Island, West Amatuli Island, and East Amatuli Island. The Chugach Islands include Elizabeth Island, Perl Island, East Chugach Island, Perl Rock, and the Naguhut Rocks.

Geology

The stratigraphy of these islands was discussed in the Kenai NWR Oil and Gas Assessment. Diorite underlies Nord and Sud islands and part of Ushagat Island. Triassic (245 Ma to 208 Ma) limestone and tuff underlies the remainder of Ushagat Island. Either diorite or Triassic limestone and tuff underlies Carl Island. The Jurassic to Cretaceous (208 Ma to 66 Ma) McHugh Complex underlies East Amatuli, West Amatuli, Sugarloaf, Perl, and Elizabeth Islands and Perl and Naguhut rocks. The Jurassic to Cretaceous Valdez Group underlies East Chugach Island.

Geochemistry

The geochemistry of the rocks in this area is discussed in the Kenai NWR Oil and Gas Assessment.

Hydrocarbon Occurrence Potential

All of the islands in this area have no oil and gas occurrence potential, a BLM mineral potential classification of O/D (figures 46 and 48). This classification is based on the igneous and metamorphic nature of the rocks in the area.

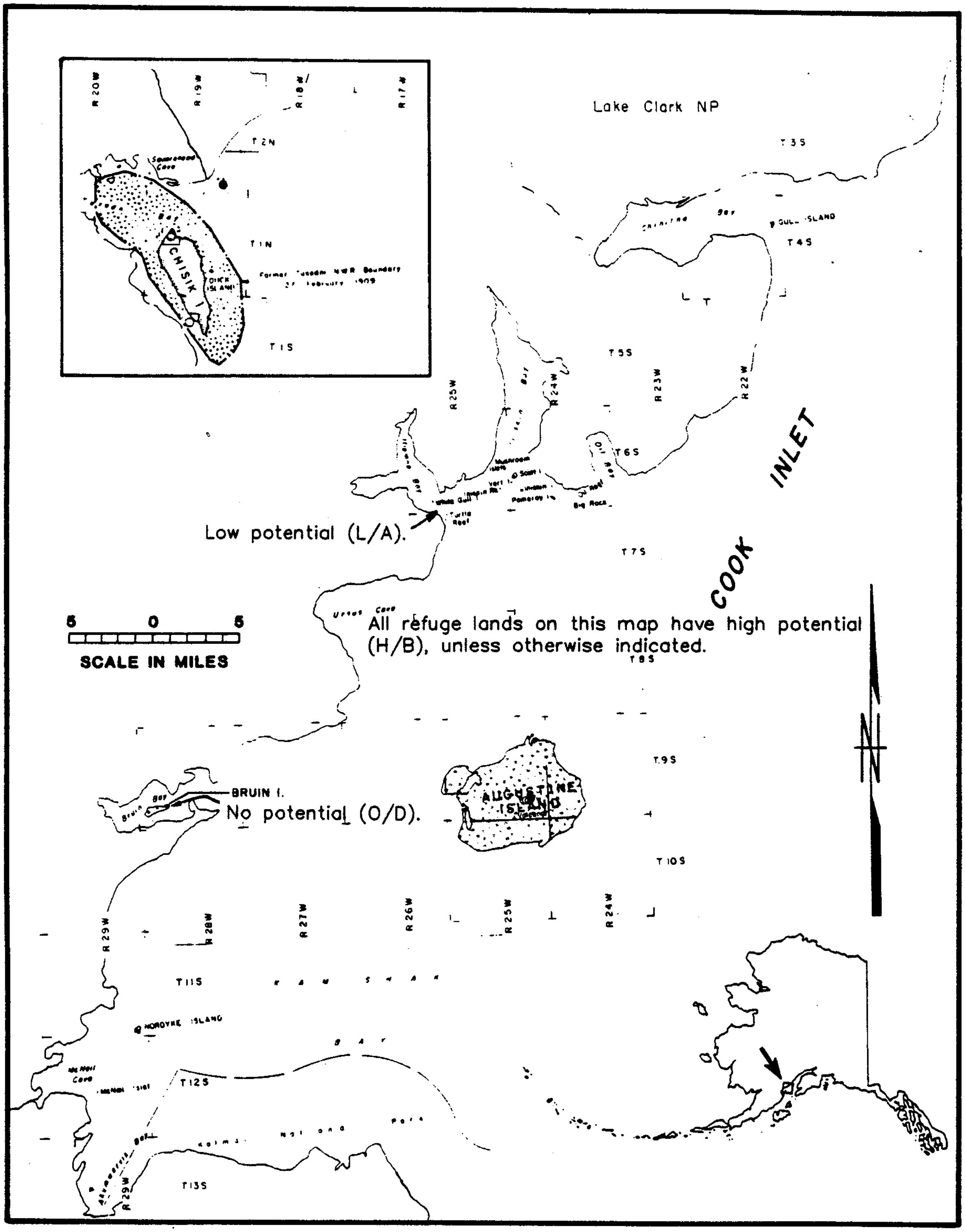


Figure 47. Hydrocarbon occurrence potential in the Gulf of Alaska Unit, Akumwarvik Bay to Gull Island.

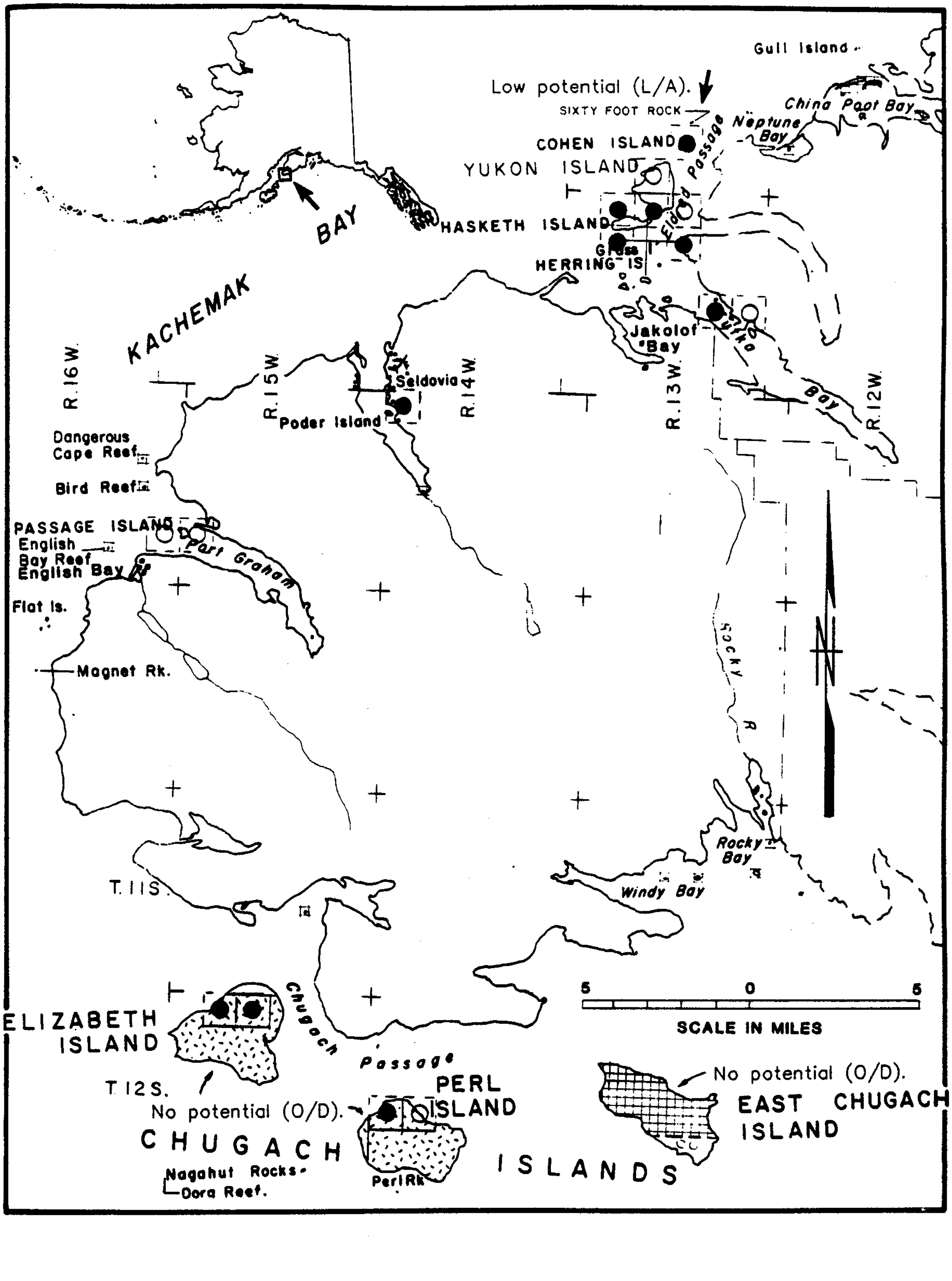


Figure 48. Hydrocarbon occurrence potential in the Gulf of Alaska Unit, China Post Bay to Rocky Bay.

Pye Islands and Chiswell Islands

The Pye Islands and Chiswell Islands include Pye Reef, Outer Island, Rabbit Island, Ragged Island, Granite Island, the Twin Islands including Dora Island, Harbor Island, Natoa Island, Beehive Island, the Chiswell Islands, Lone Rock, the Seal Rocks, Chat Island, Cheval Island, Rugged Island, Pilot Rock, and several unnamed islands.

Geology

Granite underlies all of the named islands in this area, and also probably the unnamed ones. The Valdez Group underlies the unnamed islands if they are not underlain by granite. The Valdez Group is discussed in the Kenai NWR Oil and Gas Assessment (Teseneer *et al*., 1987).

Geochemistry

The geochemistry of the rocks of the Kenai Peninsula is discussed in the Kenai NWR Oil and Gas Assessment.

Hydrocarbon Occurrence Potential

The Pye Islands and the Chiswell Islands have no hydrocarbon occurrence potential, a BLM mineral classification potential of O/D (figure 49). This classification is based on the igneous and possibly metamorphic nature of the rocks underlying the islands.

Middleton Island and Moraine Islands

Middleton Island lies in the Gulf of Alaska approximately 60 miles southwest of the mouth of the Copper River. The Moraine Islands lie in the southern side of Icy Bay.

Geology

Middleton Island and the Moraine Islands lie in the Gulf of Alaska Tertiary Province, which is considered to be an oil and gas basin. The Late Tertiary to Quaternary (24 Ma or younger) mudstone, siltstone, sandstone, and conglomerate of the Yakataga Formation underlie both Middleton Island and the Moraine Islands (Plafker, 1967). In addition, the Moraine Islands are underlain by the Middle Tertiary (57 Ma to 24 Ma) Poul Creek and Katalla formations (Bruns, 1982a).

Geochemistry

The geochemistry of the Yakataga Formation indicates that it has poor source potential while that of the Poul Creek and Katalla formations indicates that they have good source potential (Bruns, 1982a). The Katalla Formation is the probable source and is the reservoir rock for the Katalla Field.

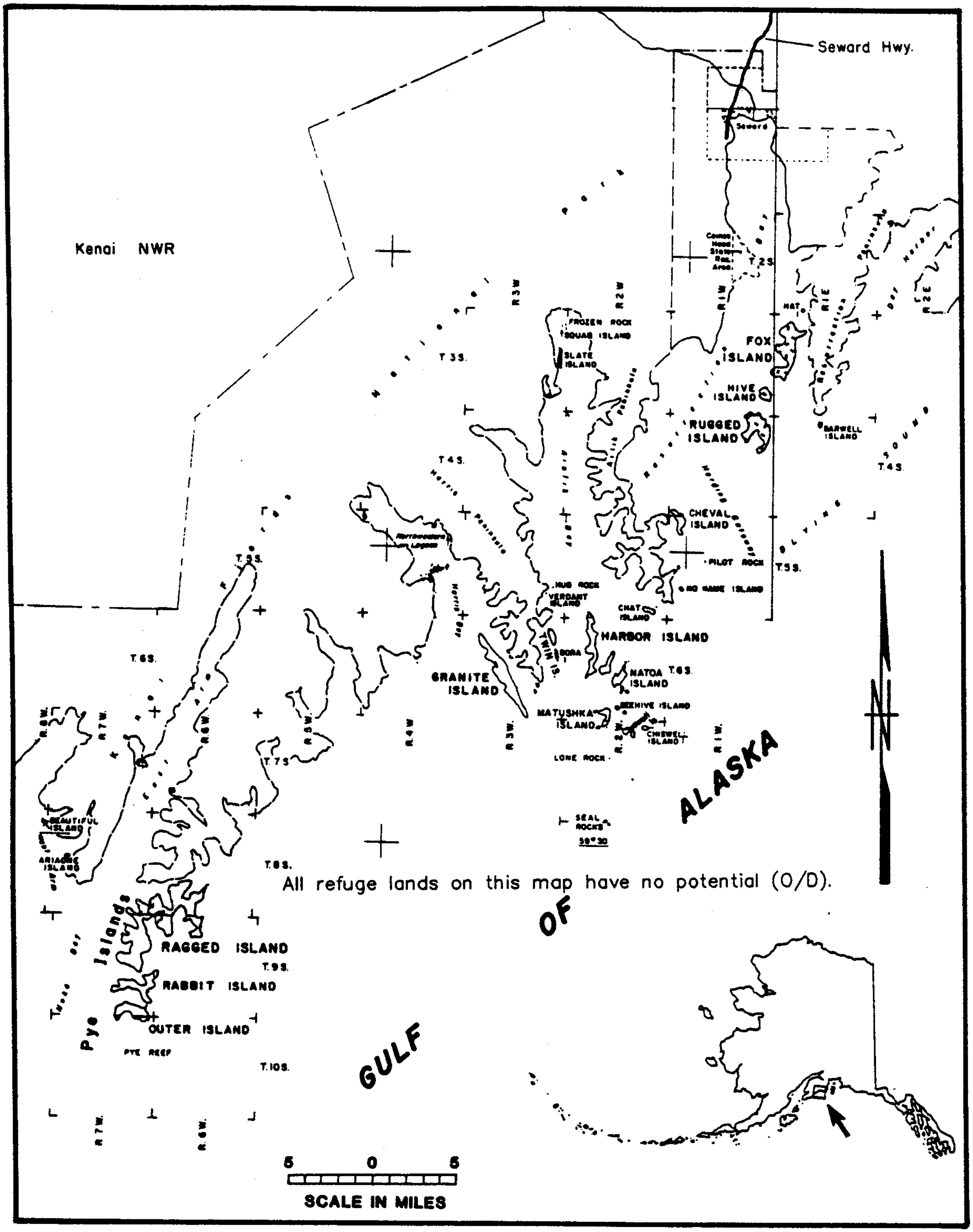


Figure 49. Hydrocarbon occurrence potential in the Gulf of Alaska Unit, Nuka Bay to Day Harbor.

Hydrocarbon Occurrence Potential

Middleton Island has a low hydrocarbon occurrence potential, a BLM mineral potential classification of L/A (figure 50). This classification is based on the poor source potential of the Yakataga Formation and the absence of the older Poul Creek and Katalla formations in the Tenneco Middleton Island Well that was drilled just to the southeast of Middleton Island.

The Moraine Islands have a high hydrocarbon occurrence potential, a BLM mineral potential classification of H/C (figure 50). This classification is based on the favorable geochemistry of the Poul Creek and Katalla formations, numerous oil seeps along the coast in the vicinity of the islands, and indications of gas in the Standard Oil of California Riou Bay No. 1 (Sec. 26, T. 23 S., R. 23 E., CRM). The well records imply a possible show of oil because they state "no commercial oil and gas" (emphasis added).

St. Lazaria Subunit

The St. Lazaria Subunit lies at the southern end of Kruzof Island and is comprised entirely of the St. Lazaria Islands.

Geology

The St. Lazaria Islands are comprised entirely of basalt flows of the Edgecumbe Volcanic sequence on a basement of metamorphic rock.

Geochemistry

No petroleum geochemistry data is available for the rocks of the St. Lazaria Islands.

Hydrocarbon Occurrence Potential

The St. Lazaria Subunit has no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 51). This classification is based on the igneous and metamorphic nature of the rocks underlying the islands.

Hazy Islands Subunit

The Hazy Islands Subunit lies to the west of Coronation Island and to the south of Baranof Island.

Geology

The Hazy Islands Subunit lies in the Craig Subterrane of the Alexander Terrane. It is probably underlain by pre-Ordovician (older than 505 Ma) metamorphic rocks and Ordovician to Triassic (505 Ma to 208 Ma) mafic to

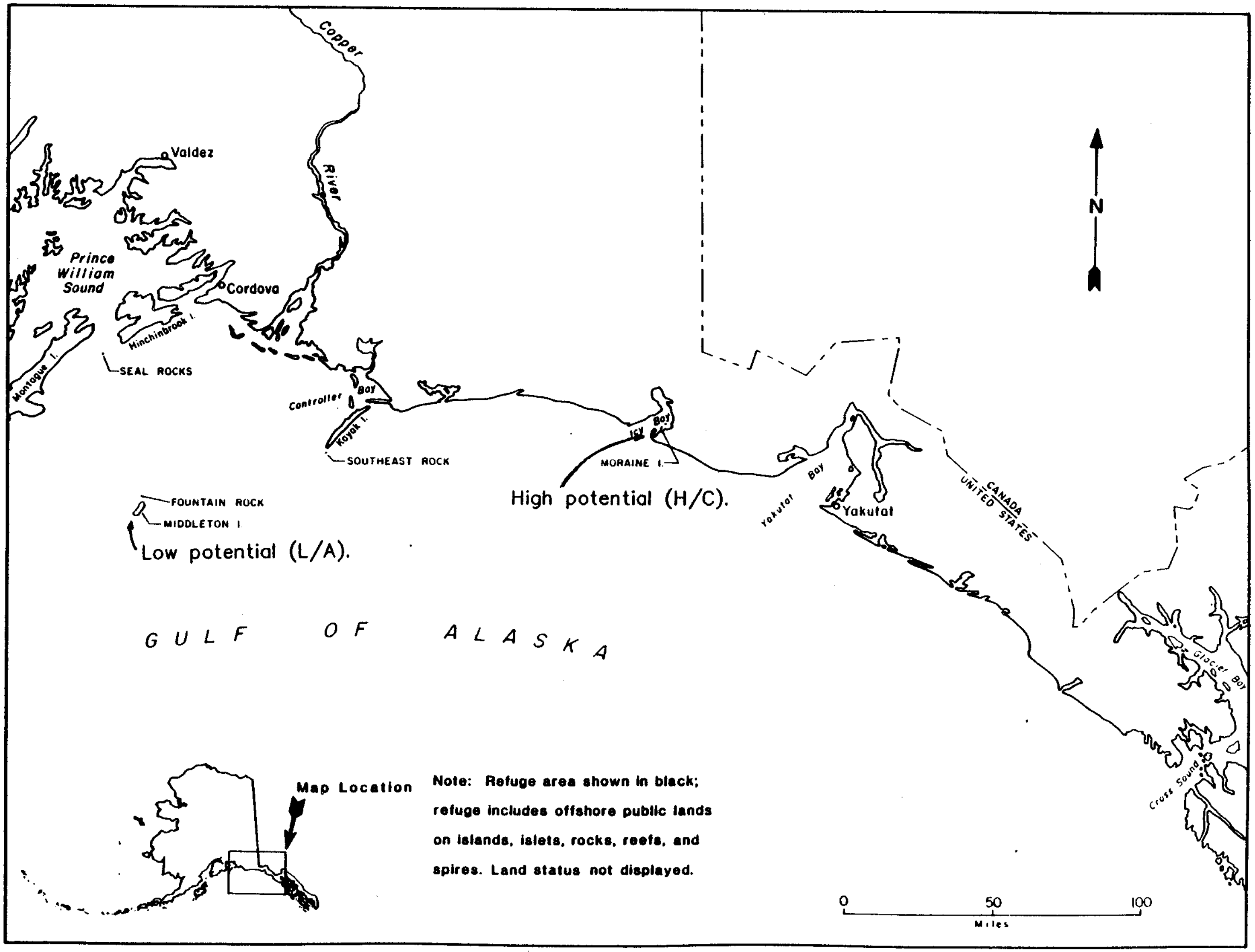


Figure 50. Hydrocarbon occurrence potential in the Gulf of Alaska Unit, Prince William Sound to Cross Sound.

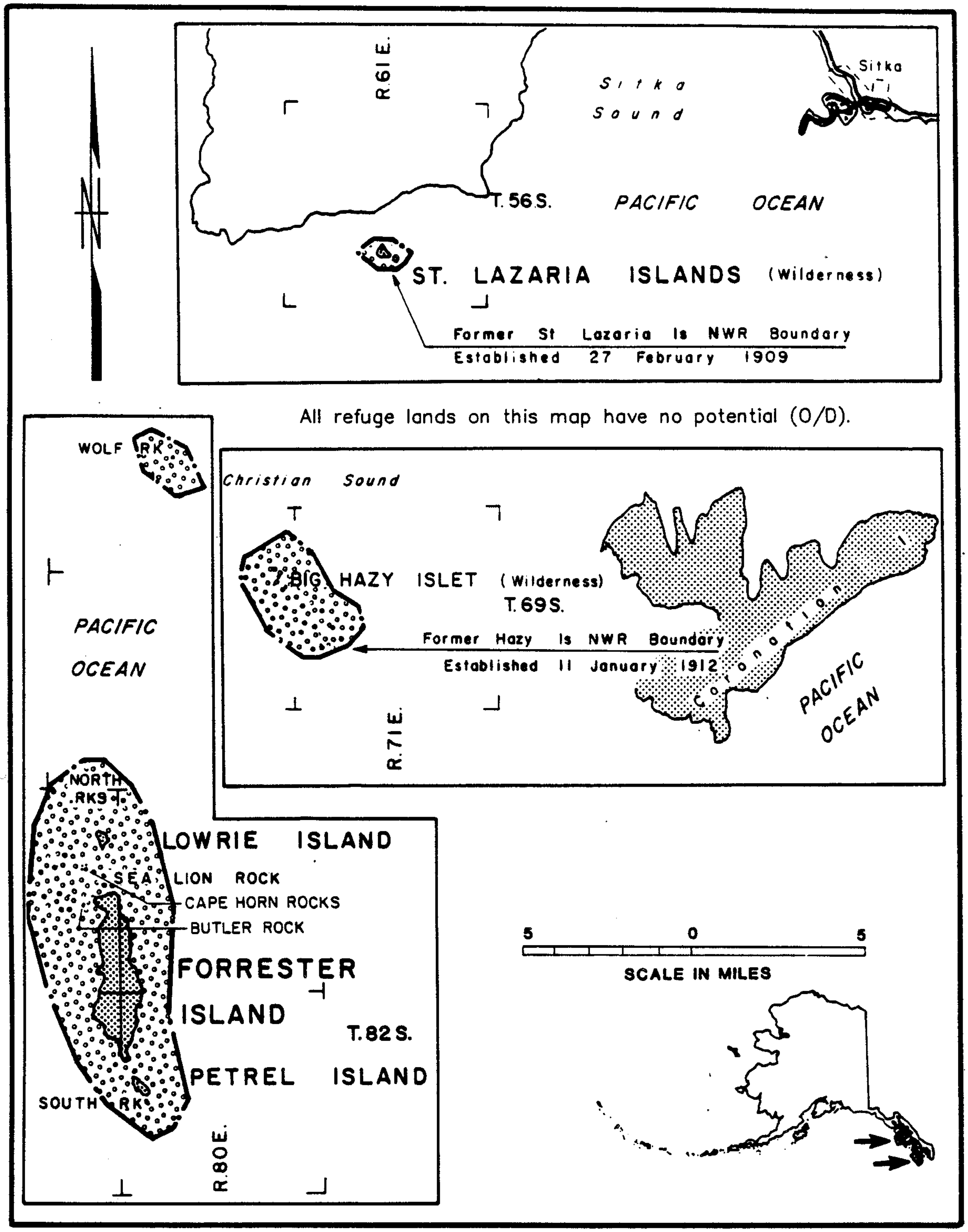


Figure 51. Hydrocarbon occurrence potential in the Gulf of Alaska Unit, the St. Lazaria Kslands, the Hazy Islands, and the Forrester Islands.

felsic volcanic rocks and terriginous clastic and carbonate rocks Monger and Berg, 1987). All of the younger rocks have undergone some metamorphism (Hudson et al., 1982). The carbonate rocks may be the limestones of the Silurian (438 Ma to 408 Ma) Heceta Limestone (Beikman, 1975).

Geochemistry

All of the rocks in the Hazy Islands Subunit should be overmature for oil or gas.

Hydrocarbon Occurrence Potential

The Hazy Islands Subunit has no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 51). This classification is based on the igneous and metamorphic nature of the rocks of the Hazy Islands Subunit.

Forrester Islands Subunit

The Forrester Islands Subunit lies to the west of Dall Island in the Gulf of Alaska. The subunit includes Wolf Rock, Sea Lion Rock, Butler Rock, the Cape Horn Rocks, South Rock, Lowrie Island, and Forrester Island.

Geology

The islands in the Forrester Islands Subunit are underlain by intrusive igneous rocks and the metamorphosed sediments of the Ordovician to Silurian (505 Ma to 408 Ma) Descon Formation (Beikman, 1980).

Geochemistry

The rocks of the islands in the Forrester Islands Subunit should be overmature for the generation of oil or gas.

Hydrocarbon Occurrence Potential

The Forrester Islands Subunit has no hydrocarbon occurrence potential, a BLM mineral potential classification of O/D (figure 51). This classification is based on the igneous and metamorphic nature of the rocks in the subunit.

Petroleum Development Scenario

The geological assessment identified three units of the Alaska Maritime National Wildlife Refuge which have a high potential of containing economical quantities of oil and/or gas. These units are the Chukchi Sea, Alaska Peninsula, and the Gulf of Alaska. After reviewing the high potential areas and the Alaska Maritime NWR lands involved, it appeared that the only unit which would be physically altered by development of these areas is the Chukchi Sea Unit.

Chukchi Sea Unit

Minimal activity would be likely on refuge lands north of Cape Lisburne. Petroleum operations offshore or in the NPRA would be designed and operated in such a manner to minimize effects on these islands, lagoons, and islets.

The Ann Stevens - Cape Lisburne and Cape Thomson refuge lands would most likely be physically impacted by the development of a petroleum field in this area.

For a field to be economic in this area, there would likely be another developed field either offshore of this area or near by in NPRA. A pipeline to the Trans-Alaska Pipeline System or a terminal facility could then be shared. These major facilities would most likely be located off of any refuge lands. Therefore, the facilities which may be located on refuge lands to develop a field in this area would be drilling/production pads, central production facilities, gathering pipelines, and roads. To protect the permafrost environment, the pads supporting these facilities and the roads would be approximately five feet thick.

Drilling/Production Pads

The drilling/production pads would support the wells, gathering facility, and associated pipelines. Areal extent of these pads may range from 15 to 25 acres. The gathering facility measures the production from each well and combines the production into one pipeline to the central production facility. If natural gas and water are reinjected on a drilling/production pad, the gathering facility would receive the natural gas and/or water from the central production facility and direct it to the appropriate disposal or injection wells. Reserve pits will also be located on these pads which will hold unusable drilling muds and cuttings. These pits would be rehabilitated when they are no longer required.

Central Production Facility (CPF)

The CPF pad would support the modules and equipment used to separate the crude oil into oil, gas, and water. Salable oil would be piped to market, produced gas would be used as fuel at the facility and the surplus reinjected into the subsurface structure. If enough gas is produced, it may be economic to bury a pipeline to nearby villages (Kotzebue, Wainwright, Nome, etc.) to use as fuel, or the gas may be piped to a LNG plant at the terminal, if one exists. Produced water would be piped to the drilling/production pads and injected into disposal wells. At least one CPF pad would also support living quarters and offices for the field personnel. Areal extent of this pad may range from 60 to 90 acres, all other CPF pads would cover 30 to 50 acres.

Roads and Gathering Pipelines

Roads would connect the drilling/production pads and the CPF pads. These roads will be built with a minimum crown width of 35 feet.

Gathering lines will run from each drilling/production pad to a CPF. One line would transport crude oil to the CPF and a parallel set of lines would transport natural gas and water from the CPF to the drilling/production pads. All three lines would most likely be placed on a single vertical support member.

Although this assessment showed only three areas of high potential in the Alaska Maritime NWR, consideration must be given to offshore discoveries and development. Since the Alaska Maritime NWR covers a large portion of the Alaska coast, it is very likely that refuge lands would be impacted by facilities required to support offshore exploration, development, and production. At a minimum, one would see a support base on or very near refuge lands. Other onshore facilities which may be needed are crude oil storage facilities, LNG plant and storage facilities, and a nearshore loading terminal.

Economic Potential

The development or economic potential of an area considers not only the geologic environment concerning the existence of mineral resources, but also the nongeologic environment.

The nongeologic environment includes such considerations as market availability, the existing infrastructure in the subject area, price projections, costs of production and marketing, anticipated rate of return, and also alternative investment opportunities.

Based on all available geologic and nongeologic information, the Alaska Maritime NWR has been determined to have either a low economic development potential or none at all (Appendix D).

A summary of the geologic petroleum potential of the subject refuge is presented in the following table.

TABLE 1

Level of Geologic (Hydrocarbon occurrence) Potential
for the Alaska Maritime National Wildlife Refuge
by Named Area 1/

Area (Unit)	None	Low	Moderate	High
Chukchi Sea	----	3	2	11
Bering Sea	9	11	3	----
Aleutian Islands	115	---	--------	----
Alaska Peninsula	60	7	9	38
Gulf of Alaska	69	7	--------	12
Total	253	28	14	61
Named Area Percent	71%	8%	4%	17%
Acreage Percent	92%	2%	1%	5%

1/ See appendix D for a listing of areas within each unit.

As can be seen from the above table, only 61 areas, or 17 percent of the total of 356 were considered to have a high geologic petroleum potential 2/. Adding to this, the areas of moderate potential increases this total to 75 areas, or 21 percent. Looking at the combined acreage of these 75 areas, which is even more significant, we find that only 6 percent of this refuge was considered to have either a high or moderate resource potential and, thus, would merit further consideration for economic development. The following table is presented to illustrate the size of these 75 areas.

TABLE 2
Areal Size of Moderate or High Resource Potential Tracts

Area	Moderate Potential	High Potential	Total	Percent of Total
1 to 125 acres	5	37	42	56%
126 to 500 acres	2	12	14	19%
Greater than 500 acres	7	12	19	25%
Total	14	61	75	100%

As can be seen from Table 2, 56 percent of the tracts (areas) that have been determined to have either a moderate or high geologic potential are in the size range of 125 acres or less. The arithmetic average size of these 42 tracts is only 31 acres, hardly the size one would think of in terms of development, so these were dropped from further consideration.

The 14 tracts in the midsize range of 126 to 500 acres represent 19 percent of those tracts in the moderate to high geologic potential category. The average size is 326 acres. Ten of these tract areas are located in the Alaska Peninsula Unit, two are in the Gulf of Alaska Unit, and one each are located in the Chukchi Sea and Bering Sea Unit, respectively.

The 19 tract areas which are the largest in size represent 25 percent of the tract areas, and range in size from 600 to 104,000 acres. The average size is 15,721 acres, or approximately 25 square miles. Fourteen of these largest high to moderate resource areas are located in the Alaska Peninsula Unit, four are in the Chukchi Sea Unit, and one is in the Bering Sea Unit.

2/ Geologic petroleum potential refers only to the probability of the presence (occurrence) of a concentration of that mineral resource. It neither refers to or implies potential for extraction or that the resource, if any, is economic or could be extracted profitably.

A review of all 33 moderate to high geologic potential tracts discussed in the last two paragraphs indicates that 24 are located in the Alaska Peninsula Unit, five in the Chukchi Sea Unit, and two each are located in the Bering Sea and Gulf of Alaska Units, respectively.

When considering the potential for economic development, we must not only look at the moderate to high geologic classifications, but also the quality and quantity of data available to reach this determination. The 31 tracts presently being considered were ranked as either an "A" or "C" (see appendix B for definitions). The quality of this data, according to definition, varies between being either insufficient or minimal to support the geologic interpretation.

As previously stated, 24 of the 33 tracts now under consideration are, for the most part, islands located just offshore from the Alaska Peninsula. Since the turn of the century, 26 wells have been drilled on the entire length of the Alaska Peninsula. Although oil and gas seeps are known to be present, and shows of oil and gas have occurred at some drill sites, all commercial ventures to date have met with failure, and industry presently has shown little interest in the area. For the five tracts located in the Chukchi Sea, the same low level of interest would be expected. The adjacent land area, from Icy Cape northeastward, is within the National Petroleum Reserve in Alaska (NPRA), which has drawn very little interest from industry. Annual surveys of industry indicate little interest in developing the area and many of the companies have assigned the area a low-priority rating. Industry interest in the tracts located in the Bering Sea Unit and Gulf of Alaska (two each) would be expected to generate much the same low level of interest relative to other leasing opportunities in Alaska.

In summary, only a low level of industry interest would be expected for any of these 33 tracts now under consideration. Lack of existing infrastructure is certainly an important point as well as presently depressed oil prices. Of even more significance is the presence of the North Slope area, which holds great promise. At least through the next 20 years, industry interest is expected to sharply focus on this area compared to other leasing opportunities offered in Alaska

Current technology exists that would allow exploration and development of potential hydrocarbon resources from this refuge, should commercial quantities be discovered; so the interest in opening this area to exploration is dictated by the resource potential and economic viability of oil and gas development in the area.

Price Projections

Recent petroleum price projections compiled from a variety of sources (Anonymous, 1985a, 1985d, 1985c, and 1986a-f) are significantly lower than previous forecasts completed earlier in the 1980s (Appendix C, table 1). The range of oil prices projected in these current forecasts vary from $18 to $42 per barrel by the year 2000 (constant 1984/85 dollars). With such a wide spread in forecasts, it is difficult to assess future impacts of this variable on future exploration activities. It may be of interest to note that both a private research firm and a major oil company forecast a high case crude oil price of $35/barrel, whereas the most optimistic level of $42/barrel was a forecast of the U.S. Department of Energy (DOE). The DOE mid-range forecast of $36.75 is less than $2/barrel higher than that of the high case for private sector. This level ($36.75/barrel by the year 2000) is approximately $5/barrel, or 12 percent, less than the average annual refiner's cost of imported crude in 1981/82 (constant 1984 dollars). This scenario does reflect an optimistic picture as compared to the current pricing structure and would be expected to provide incentives for future exploration/ production of the Alaska Maritime NWR.

Other forecasts from the same sources indicate an upward trend in petroleum demand, but conversely project a decline in domestic production which is indicative of a decrease in domestic exploration activities.

One last petroleum price projection that should be considered is the scenario presented by Arlon Tussing, a Seattle-based energy economist (Tussing and Bayless, 1987). Mr. Tussing, in late 1980, against all conventional price projections, correctly forecast that international oil prices would soon collapse. In January 1984, prior to the concern of most energy forecasters, he stated that we were headed for a 10-year cycle of falling prices, and he projected that oil would soon drop within the range of $12 to $20 per barrel. To date, this forecast has been quite accurate.

Mr. Tussing's latest forecast is even more foreboding, as he expects oil prices in constant dollars (1987) to remain within a range of $10 to $20 a barrel through the rest of the century. Beyond this timeframe, he expects energy prices to decline even further.

The basis for this scenario is "fuel switching." Mr. Tussing states that "many" of the industrial users are now equipped to use alternate fuels such as oil, gas, or coal, depending on the prevailing price. He believes that the exceptional high prices during the six-year period between 1979 and 1985 were possible only because heavy industrial users were not at that time equipped to switch fuels and were heavily dependent on oil as a bulk fuel. This stemmed from the fact that exceptionally low oil prices prevailed in the 1950s and 1960s, and this trend was expected to continue ad-infinitum. He points out that for a century, between 1878 and 1978, crude oil prices never exceeded $15/barrel in 1986 dollars, and the average wellhead price during this 100-year period was between $8 and $9/barrel. Mr. Tussing believes that the long-term price trend for oil can only be downward.

The wide divergence in oil price projections just presented are indicative of the future uncertainty which exists in the national petroleum industry. As we have seen, though, most mainline economists are forecasting an upward trend in long-term bulk oil prices. Although this is considered a promising sign for the industry as a whole, this is foreshadowed by forecasts of a long-term decline in U.S. production. This decline was brought on by a general cutback in drilling and production activities by U.S. petroleum companies triggered by an excess world supply and resultant low product prices. Future expansionary efforts by the petroleum industry would be anticipated to take place in areas where capital costs can be held down, or, in lieu of this, in areas of great promise.

Overview

In 1986, Alaska contributed nearly 20 percent of domestic petroleum production (United States Department of Energy, Energy Information Administration, 1987). In comparison, Alaska is a relatively minor producer of natural gas, with production of approximately 300 billion cubic feet peryear in 1986 (United States Department of Energy, Energy Information Administration, 1987a). However, Alaska is an exporter of natural gas in the form of liquified natural gas (LNG), which is primarily shipped to Japan.

Fundamental changes in the petroleum industry since the early 1970s will certainly be a force in shaping the industry's future. This period brought two major crude oil price shocks, rapid expansion in petroleum demand and heavy reliance on foreign sources of supply to meet domestic needs. Similarly, the consumer experienced shortages in natural gas supply which resulted in a new era of gas price regulation (see Appendix C for a detailed discussion of these changes). The rapid growth of the energy sector in the late 1970s and early 1980s was a result of the highest petroleum prices ever experienced by the industry. This set the stage for a period of energy conservation efforts, followed by declining demand and excess world productive capacity with falling petroleum prices. By the middle of 1986, crude oil prices had dropped to levels at or below prices received in 1973, before the Arab oil embargo. Natural gas price increases stimulated drilling and production in the early 1980s, which has resulted in domestic surplus capacity (gas bubble) and depressed prices. The present unstable nature of the oil and gas industry has resulted in a great deal of restructuring within the industry, and expectations for the future are very uncertain.

Most recent long-term price forecasts project an upward trend that will be realized in the 1990s and possibly beyond (see Appendix C for specific prices and trends). Domestic petroleum demand is expected to rise slightly above the 1985 level of 15.7 million barrels per day to a range from 15.9 to 18.1 million barrels per day by the year 2000. Natural gas demand could also increase from 17.4 trillion cubic feet per year in 1985 to a possible range from 17.1 to 20.4 trillion cubic feet per year in the year 2000. In contrast, domestic production of petroleum and natural gas is projected to decline below

1985 levels by the year 2000 (see Appendix C for a more detailed discussion of historic and future petroleum and natural gas demand and supply relationships). Therefore, the United States' dependency on foreign sources of hydrocarbon supplies is expected to increase above current levels. Based on these projections, there is a considerable gap between domestic comsumption and production that can only be filled nationally by exploring new areas and developing any commercial discoveries that are made.

In the future, if the Alaska Maritime NWR were opened to oil and gas exploration and development, some benefits would accrue to the local economy through the expenditure of explorational dollars, with some small-scale benefits to the State. Economic benefits would, of course, be dependent on industry's interest in the area and investing the necessary capital for development. Presently, and at least through the turn of the century, it is not expected that industry would have significant interest in the area and would be more inclined to expend their exploration dollars in areas of greater promise. Any long-term benefits that would accrue, would of course be dependent on locating commercial quantities of oil and gas that could be recovered from a favorable economic viewpoint.

Bibliography

Ahlbrandt, T. S., 1979, Introduction to geologic studies of the Nanushuk Group, North Slope, Alaska, in Ahlbrandt, T. S., ed., Preliminary geologic, petrologic, and paleontologic results of the study of Nanushuk Group rocks, North Slope, Alaska: U.S. Geological Survey Circular 794, p. 1-4.

Ahlbrandt, T. S., Huffman, A. C., Jr., Fox, J. E., and Pasternack, I., 1979, Depositional framework and reservoir-quality studies of selected Nanushuk Group outcrops, North Slope, Alaska, in Ahlbrandt, T. S., ed., Preliminary geologic, petrologic, and paleontologic results of the study of Nanushuk Group rocks, North Slope, Alaska: U.S. Geological Survey Circular 794, p. 14-31.

Allaway, W. H., Jr., and Miller, J. W., 1984, Newly recognized sedimentary environments in the Shelikof Formation, Alaska, in Coonrad, W. L., and Elliott, R. L., , eds., The United States Geological Survey in Alaska -- accomplishments during 1981: U.S. Geological Survey Circular 868, p. 34-37.

Allison, R. C., 1977, Late Paleogene and Neogene faunas of the Gulf of Alaska region -- correlation, paleoclimatology, and paleozoogeography (abs.): Abstracts with Programs, Geological Society of America, v. 9, no. 7, p. 876.

Allison, R. C., and Marincovich, L., Jr., 1981, A Late Oligocene or earliest Miocene molluscan fauna from Sitkinak Island, Alaska: U.S. Geological Survey Professional Paper 1233, 11 p., 3 plates.

Andreasen, G. E., Dempsey, W. J., Vargo, J. L., et al., 1963, Aeromagnetic map of parts of the Ugashik and Karluk quadrangles, Alaska: U.S. Geological Survey Geophysical Investigations Map GP-354, 1 sheet, scale 1:125,000.

Anonymous, 1979, Oil and gas resources -- Alaska, in Geological Survey research 1979: U.S. Geological Survey Professional Paper 1150, p. 23-25.

Anonymous, 1980, Geological Survey research 1980: U.S. Geological Survey Professional Paper 1175, 459 p.

Anonymous, 1982, Geological report Peard test well No. 1: Husky Oil NPR Operations, Inc.

Anonymous, 1984a, Annual energy outlook, 1983, with projections to 1995: Energy Information Administration, U.S. Department of Energy, DOE/EIA-0383(83), May 1984.

Anonymous, 1984b, Natural gas annual: Energy Information Administration, U.S. Department of Energy, DOE/EIA-0131(84), December 1984.

Anonymous, 1984c, 1984 Statistical report: Alaska Oil and Gas Conservation Commission, 187 p.

Anonymous, 1985a, Annual energy review, 1984: Energy Information Administration, U.S. Department of Energy, DOE/EIA-0384(84), April 1985.

Anonymous, 1985b, Alaska Maritime National Wildlife Refuge: U.S. Government Printing Office, 1 sheet.

Anonymous, 1985c, Norton Basin Sale 100 -- Final Environmental Impact Statement: U.S. Minerals Management Service OCS EIS/EA MMS 85-0085, 2 volumes.

Anonymous, 1985d, Energy conservation indicators, 1984 annual report: Energy Information Administration, U.S. Department of Energy, DOE/EIA-0441(84), December 1985.

Anonymous, 1985e, National energy policy plan projections to 2010: Office of Policy, Planning, and Analysis, U.S. Department of Energy, December 1985.

Anonymous, 1986a, Energy review executive summary: Data Resources Incorporated, Spring 1986.

Anonymous, 1986b, Monthly energy review: Energy Information Administration, U.S. Department of Energy, DOE/EIA-0035 (85/12), March 1986.

Anonymous, 1986c, Petroleum supply monthly: Energy Information Administration, U.S. Department of Energy, DOE/EIA-0109 (86/01), March 1986.

Anonymous, 1986d, Natural gas monthly: Energy Information Administration, U.S. Department of Energy, DOE/EIA-0130 (86/01), March 1986.

Anonymous, 1986e, International energy outlook 1985, with projections to 1995: Energy Information Administration, U.S. Department of Energy, DOE/EIA-0484 (85), March 1986.

Anonymous, 1986f, World energy outlook, Economics Department, Chevron Corporation, San Francisco, California, June 1986.

Anonymous, 1986g, Hope Basin stratigraphic project: Alaska Division of Geological and Geophysical Surveys for the University of Texas at Austin for U.S. Department of the Interior, Minerals Management Service Studies Related to Continental Margins, 63 p.

Anonymous, 1987, Chukchi Sea Oil and Gas Lease Sale 109 -- final environmental impact statement: U.S. Minerals Management Service OCS EIS/EA MMS 87-0110, 2 volumes.

Armentrout, J. M., 1979, Cenozoic stratigraphy, Kodiak Island Archipelago, Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 3, p. 66.

Armentrout, J. M., 1980, A new late Oligocene unit, Sitkinak Island, Trinity Islands Group, Kodiak Island Archipelago, Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 12, no. 3, p. 94.

Armentrout, J. M., and Anderson, G. A., 1980, Hydrocarbon potential of Sitkalidak Formation, Eocene submarine fan complex, Kodiak Island Archipelago, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 671.

Armstrong, A. K., and Mamet, B. L., 1977, Carboniferous microfacies, microfossils, and corals, Lisburne Group, Arctic Alaska: U.S. Geological Survey Professional Paper 849, 144p., 47 plates.

Armstrong, A. K., Mamet, B. L., and Dutro, J. T., Jr., 1971, Lisburne Group, Cape Lewis-Niak Creek, northwestern Alaska, in Geological Survey research 1971, chapter B: U.S. Geological Survey Professional Paper 750-B, p. B23-B34.

Aud, B. W., 1979, Hydrocarbon potential in Gulf of Alaska -- what happened?: The Oil and Gas Journal, v. 77, no. 5, p. 218-225.

Baldauf, J. G., 1981, Diatoms from late Quaternary sediments from the Navarin Basin province, in Carlson, P. R., and Karl, H. A., eds., Seafloor geologic hazards, sedimentology, and bathymetry -- Navarin Basin province, northwestern Bering Sea: U.S. Geological Survey Open-File Report 81-1217, p. 100-113.

Banet, A. C., Jr., 1983, A geochemical profile of Tunalik No. 1 well, National Petroleum Reserve in Alaska: U.S. Geological Survey Open-File Report 83-627, 19 p., 2 sheets.

Barnes, D. F., 1977, Bouguer gravity map of Alaska: U.S. Geological Survey Geophysical Investigations Map GP-913, 1 sheet, scale 1:2,500,000.

Barnes, F. F., 1967, Coal resources of the Cape Lisburne-Colville River region, Alaska: U.S. Geological Survey Bulletin 1242-E, p. E1-E37.

Barnes, F. F., and Cobb, E. H., 1959, Geology and coal resources of the Homer district, Kenai coal field, Alaska: U.S. Geological Survey Bulletin 1058-F, p. 217-260.

Barnes, I., Plafker, G., White, L. D., and Armstrong, A. K., 1982, Potential natural gas in the Gulf of Alaska indicated by calcite depleted in carbon-13, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 143-146.

Barnes, P. W., Reimnitz, E., Gustafson, C. W., and Larsen, B. R., 1973, USGS marine geologic studies in the Beaufort Sea off northern Alaska, 1970 through 1972; data type and location: U.S. Geological Survey Open-File Report 73-18, 38 p.

Barth, T. F. W., 1956, Geology and petrology of the Pribilof Islands, Alaska: U.S. Geological Survey Bulletin 1028-F, p. 101-160.

Bartsch-Winkler, S., and Huffman, A. C., 1979, Petrographic study of some surface and subsurface sandstone, NanushukGroup, North Slope, Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 3, p. 68.

Bartsch-Winkler, S., and Huffman, A. C., 1981a, Petrography of the Nanushuk Group and Torok Formation: U.S. Geological Survey Open-File Report 81-1222, 62 p.

Bartsch-Winkler, S., and Huffman, A. C., 1981b, Compositional variation in sandstones of the Nanushuk Group, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B6-B8.

Bascle, R., Evans, D., Seidlitz, A., and Borkoski, J., 1987, Oil and gas assessment of the Alaska Peninsula/Becharof National Wildlife Refuges: U.S. Department of the Interior, Bureau of Land Management, unpublished report prepared for the U.S. Fish and Wildlife Service, 76 p., 4 sheets.

Bayer, K. C., Mattick, R. E., Plafker, G., and Bruns, T. R., 1977, Refraction studies between Icy Bay and Kayak Island eastern Gulf of Alaska: U.S. Geological Survey Open-File Report 77-550, 29 p.

Bayless, A., 1987, A bear in the oil patch: Wall Street Journal, April 28, 1987, p. 38.

Becker, A. A., Johannson, T. M., and Johnson, M. L., 1979, Hydrocarbon potential of central Gulf of Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 63, no. 3, p. 417-418.

Beikman, H. M., 1974, Preliminary geologic map of the southwest quadrant of Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-611, 2 sheets, scale 1:1,000,000.

Beikman, H. M., 1975a, Preliminary geologic map of southeastern Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-673, 2 sheets, scale 1:1,000,000.

Beikman, H. M., 1975b, Preliminary geologic map of the Alaska Peninsula and Aleutian Islands: U.S. Geological Survey Miscellaneous Field Studies Map MF-764, 2 sheets, scale 1:1,000,000.

Beikman, H. M., 1980, Geologic map of Alaska: U.S. Geological Survey, 2 sheets, scale 1:2,500,000.

Beikman, H. M., and Lathram, E. H., 1976, Preliminary geologic map of northern Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-789, 2 sheets, scale 1:1,000,000.

Berg, H. C., 1972, Geologic map of Annette Island, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-684, 8 p., 1 sheet, scale 1:63,360.

Berg, H. C., 1979, Significance of geotectonics in the metallogenesis and resource appraisal of southeastern Alaska -- a progress report, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B116-B118.

Bird, K. J., 1981, Petroleum exploration of the North Slope in Alaska, USA: U.S. Geological Survey Open-File Report 81-227, 43 p.

Bird, K. J., 1982, Rock-unit reports of 228 wells drilled on the North Slope, Alaska: U.S. Geological Survey Open-File Report 82-278, 106 p.

Bird, K. J., and Andrews, J., 1979, Subsurface studies of the Nanushuk Group, North Slope, Alaska, in Ahlbrandt, T. S., ed., Preliminary geologic, petrologic, and paleontologic results of the study of Nanushuk Group rocks, North Slope, Alaska: U.S. Geological Survey Circular 794, p. 32-41.

Bishop, R. A., 1982, Undrilled reserves in Cook Inlet oil fields, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 66, no. 7, p. 959.

Blanton, S. L., Jr., 1979, Geology of the Bering Shelf, in Sisson, A., ed., The relationship of plate tectonics to Alaskan geology and resources, proceedings of the sixth Alaska Geological Society symposium held April 4-6, 1977, at Anchorage, Alaska: Alaska Geological Society, Anchorage, Alaska, p. E1-E5.

Blueford, J. R., 1981, Radiolaria from the Navarin Basin province, Bering Sea, in Carlson, P. R., and Karl, H. A., eds., Seafloor geologic hazards, sedimentology, and bathymetry -- Navarin Basin province, northwestern Bering Sea: U.S. Geological Survey Open-File Report 81-1217, p. 130-137.

Blueford, J. R., 1986, New radiolarian data from the Orca Group, Prince William Sound, in Bartsch-Winkler, S., and Reed, K. M., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1985: U.S. Geological Survey Circular 978, p. 33-34.

Box, S. E., and Patton, W. W., Jr., 1985, Early Cretaceous evolution of Yukon-Koyukuk basin and its bearing on development of Brookian orogenic belt (abs.): American Association of Petroleum Geologists Bulletin, v. 69, no. 4, p. 657.

Box, S. E., Patton, W. W., Jr., and Carlson, C., 1985, Early Cretaceous evolution of the northeastern Yukon-Koyukuk basin, west-central Alaska, in Bartsch-Winkler, S., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1984: U.S. Geological Survey Circular 967, p. 21-24.

Brew, D. A., and Ford, A. B., 1978, Megalineament in southeastern Alaska marks southwest edge of Coast Range batholithic complex: Canadian Journal of Earth Science, v. 15, no. 11, p. 1763-1772.

Brew, D. A., and Ford, A. B., 1984, Tectonostratigraphic terranes in the Coast plutonic-metamorphic complex, southeastern Alaska, in Reed, K. M., and Bartsch-Winkler, S., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1982: U.S. Geological Survey Circular 939, p. 90-93.

Brew, D. A., and Ford, A. B., 1985, Southeastern Alaska tectonostratigraphic terranes revisited (abs.): American Association of Petroleum Geologists Bulletin, v. 69, no. 4, p. 657.

Brew, D. A., and Morrell, R. P., 1979a, Intrusive rock belts of southeastern Alaska, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B116, B119-B121.

Brew, D. A., and Morrell, R. P., 1979b, The Wrangell terrane ("Wrangellia") in southeastern Alaska -- the Tarr Inlet suture zone with its northern and southern extensions, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishments during 1978: U.S. Geological Survey Circular 804-B, p. B121-B123.

Brigham, J. K., 1984, Marine stratigraphy and amino acid geochronology of the Gubik Formation, western Arctic Coastal Plain, Alaska, in Reed, K. M., and Bartsch-Winkler, S., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1982: U.S. Geological Survey Circular 939, p. 5-9.

Brigham, J. K., 1985, Marine stratigraphy and amino-acid geochronology of the Gubik Formation, western Arctic Coastal Plain, Alaska: U.S. Geological Survey Open-File Report 85-381, 218 p., 2 sheets.

Brockway, R. G., 1983, Geological report Ikpikpuk test well No. 1: Husky Oil Operations, Inc., Anchorage.

Brosge, W. P., and Tailleur, I. L., 1971, Northern Alaska petroleum province, in Cram, I. H., ed., Future petroleum provinces of the United States -- their geology and potential: American Association of Petroleum Geologists Memoir 15, p. 68-99.

Brosge, W. P., and Tailleur, I. L., 1970, Depositional history of northern Alaska, in Adkison, W. L., and Brosge, M. M., eds., Geological seminar on the North Slope of Alaska: Pacific Section, American Association of Petroleum Geologists, Los Angeles, California, p. D1-D18.

Bruns, T. R., 1976, Structural style of part of the Outer Continental Shelf in the Gulf of Alaska Tertiary Province, in Cobb, E. H., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1975: U.S. Geological Survey Circular 733, p. 13-14.

Bruns, T. R., 1979, Late Cenozoic structure of the continental margin, northern Gulf of Alaska, in Sisson, A., ed., The relationship of plate tectonics to Alaskan geology and resources, proceedings of the sixth Alaska Geological Society symposium held April 4-6, 1977, at Anchorage, Alaska: Alaska Geological Society, Anchorage, Alaska, p. I1-I30.

Bruns, T. R., 1982a, Hydrocarbon resource report for proposed OCS lease sale 88 -- southeast Alaska, Northern Gulf of Alaska, Cook Inlet, and Shelikof Strait, Alaska: U.S. Geological Survey Open-File Report 82-928, 133 p.

Bruns, T. R., 1982b, Structure and petroleum potential of the continental margin between Cross Sound and Icy Bay, northern Gulf of Alaska: U.S. Geological Survey Open-File Report 82-929, 64 p.

Bruns, T. R., 1983, Structure and petroleum potential of the Yakutat segment of the northern Gulf of Alaska continental margin: U.S. Geological Survey Miscellaneous Field Studies Map MF-1480, 22 p., 3 sheets, scale 1:500,000.

Bruns, T. R., Atwood, T. J., and Childs, J. R., 1981, Free-air gravity map, Cross Sound to Icy Bay, northern Gulf of Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1306, 1 sheet, scale 1:1,500,000.

Bruns, T. R., and Bayer, K., 1977, Multichannel seismic reflection data acquired on the M/V Cecil H. Green in the Gulf of Alaska, June-August 1975: U.S. Geological Survey Open-File Report 77-352, 22 p.

Bruns, T. R., and Plafker, G., 1977, Structure of continental shelf, eastern Gulf of Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 61, no. 5, p. 773.

Bruns, T. R., and Schwab, W. C., 1983, Structure maps and seismic stratigraphy of the Yakataga segment of the continental margin, northern Gulf of Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1424, 20 p., 4 sheets, scale 1:250,000.

Bruns, T. R., Vallier, T. L., Pickthorn, L. B., and von Huene, R., 1987, Volcanic-arc dacite and Early Miocene basalt dredged from the Shumagin margin, Alaska, _in_ Hamilton, T. D., and Galloway, J. P., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 143-146.

Bruns, T. R., and von Huene, R., 1985, Structure of Shumagin continental margin, western Gulf of Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 69, no. 4, p. 657.

Bruns, T. R., von Huene, R., Culotta, R. C., and Lewis, S. D., 1985, Summary geologic report for the Shumagin Outer Continental Shelf (OCS) planning area, Alaska: U.S. Geological Survey Open-File Report 85-32, 58 p.

Bruynzeel, J. W., Guldenzopf, E. C., and Pickard, J. E., 1982, Petroleum exploration of NPRA, 1974-1981; Tetra Tech, Inc., Houston, Texas: Tetra Tech Report No. 8200, USGS-Husky Contract No. 14-08-0001-16474, Husky-Tetra Tech Subcontract No. GC-81-5, prepared for Husky Oil NPR Operations, Inc.

Budnik, R. T., 1974, The geologic history of the Valdez Group, Kenai Peninsula, Alaska -- deposition and deformation at a Late Cretaceous consumptive plate margin: unpublished PhD dissertation, University of California, Los Angeles, California, 139 p., 2 plates.

Burk, C. A., 1965, Geology of the Alaska Peninsula -- island arc and continental margin: Geological Society of America Memoir 99, 250 p., 3 sheets, scales 1:250,000 and 1:1,000,000.

Burkhard, N., Bruns, T., McHendrie, G, and Ruppel, B., 1980, Free-air gravity anomaly map, eastern Gulf of Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1172, 1 sheet, scale 1:500,000.

Burlin, Y. K., Pushcharovsky, Y. M., and Sokolov, B. A., 1976, Oil- and gas-bearing basins of Circum-Pacific belt -- summary (abs.), in Halbouty, M. T., Maher, J. C., and Lian, H. M., eds., Circum-Pacific energy and mineral resources: American Association of Petroleum Geologists Memoir 25, p. 176.

Burns, L. E., Pessel, G. H., and Sleep, N., 1983, An island arc gabbroic complex in southern Alaska (abs.): EOS, v. 64, no. 9, p. 87.

Burrell, P. D., 1984, Cretaceous plutonic rocks, Mitkof and Kupreanof Islands, Petersburg quadrangle, southeastern Alaska, in Coonrad, W. L., and Elliott, R. L., , eds., The United States Geological Survey in Alaska -- accomplishemnts during 1981: U.S. Geological Survey Circular 868, p. 124-126.

Byers, F. M., Jr., 1955, Geology of Umnak and Bogoslof Islands, Alaska: U.S. Geological Survey Bulletin 1028-L, p. 267-369.

Capps, S. R., 1934, Notes on the geology of the Alaska Peninsula and Aleutian Islands: U.S. Geological Survey Bulletin 857-D, p. 141-153.

Capps, S. R., 1937, Kodiak and vicinity, Alaska: U.S. Geological Survey Bulletin 868-B, p. 93-134.

Carden, J. R., and Forbes, R. B., 1976, Discovery of blueschists on Kodiak Island, in Short notes on Alaskan geology -- 1976: Alaska Division of Geology and Geophysics Geologic Report 51, p. 19-22.

Carlson, P. R., Fischer, J. M., and Karl, H. A., 1981, Morphology of Navarin Basin province, in Carlson, P. R., and Karl, H. A., eds., Seafloor geologic hazards, sedimentology, and bathymetry -- Navarin Basin province, northwestern Bering Sea: U.S. Geological Survey Open-File Report 81-1217, p. 10-14.

Carlson, P. R., Golan-Bac, M., Karl, H. A., and Kvenvolden, K. A., 1985, Seismic and geochemical evidence for shallow gas in sediment on Navarin continental margin, Bering Sea: American Association of Petroleum Geologists Bulletin, v. 69, no. 3, p. 422-436.

Carlson, P. R., Karl, H. A., Johnson, K. A., and Fischer, J. M., 1982, Submarine canyons flanking Navarin Basin, Bering Sea, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 139-141.

Carlson, P. R., Molina, B. F., Kittelson, S. C., and Hampson, J. C., Jr., 1977, Map of distribution of bottom sediments on the continental shelf, Gulf of Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-876, 2 sheets, scale 1:250,000.

Carlson, P. R., Plafker, G., Bruns, T. R., and Levy, W. P., 1979, Seaward extension of the Fairweather fault, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B135-B139.

Carter, R. D., Mull, C. G., Bird, K. J., and Powers, R. B., 1977, The petroleum geology and hydrocarbon potential of Naval Petroleum Reserve No. 4 North Slope, Alaska: U.S. Geological Survey Open-File Report 77-475, 61 p.

Case, J. E., Barnes, D. F., Detterman, R. L., Morin, R. L., and Sikora, R. F., 1981, Gravity anomaly and interpretation map, Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1053-J, 5 p., 1 sheet, scale 1:250,000.

Case, J. E., Cox, D. P., Detra, D. E., Detterman, R. L., and Wilson, F. H., 1982, Aeromagnetic survey of the Chignik and Sutwik Island quadrangles, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 88-89.

Case, J. E., Sikora, R., Tysdal, R. G., Barnes, D. F., and Morin, R., 1979, Geologic interpretation of the gravity map of the Seward and Blying Sound quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-880-C, 1 sheet, scale 1:250,000.

Case, J. E., Tysdal, R. G., Hillhouse, J. W., and Gromme, C. S., 1979, Geologic interpretation of aeromagnetic map of the Seward and Blying Sound quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-880-D, 2 sheets, scale 1:250,000.

Cass, J. T., 1959, Reconnaissance geologic map of the Norton Bay quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-286, 1 sheet, scale 1:250,000.

Cass, J. T., 1959, Reconnaissance geologic map of the Nulato quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-291, 1 sheet, scale 1:250,000.

Childs, J. R., Cooper, A. K., Marlow, M. S., and Scholl, D. W., 1977, Sonobouy refraction data from the Bering Sea Basin (abs.): Abstracts with Programs, Geological Society of America, v. 9, no. 7, p. 927-928.

Childs, J. R., Cooper, A. K., and Wright, A. W., 1981, Residual magnetic map of the Umnak Plateau region, southeastern Bering Sea: U.S. Geological Survey Geophysical Investigations Map GP-939, 1 sheet, 1:1,000,000.

Childs, J. R., Nagistrale, H. W., and Cooper, A. K., 1985, Free-air gravity map of the Bering Sea: U.S. Geological Survey Miscellaneous Field Studies Map MF-1728, 1 sheet, scale 1:2,500,000.

Childs, J. R., Scholl, D. W., and Vallier, T. , 1981, Onshore and offshore studies, Amlia Island area, Aleutian Ridge, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B134-B137.

Churkin, M., Jr., 1973, Geologic concepts of Arctic Ocean basin, in Pitcher, M. G., ed., Arctic geology -- proceedings of the second international symposium on arctic geology, February 1-4, 1971, San Francisco, California: American Association of Petroleum Geologists Memoir 19, Tulsa, Oklahoma, p. 485-499.

Churkin, Jr., 1983, Tectonostratigraphic terranes of Alaska and northeastern USSR -- a record of collision and accretion (abs.), in Hashimoto, M., and Uyeda, S., eds., Accretion tectonics in the circum-Pacific region: Advances in Earth and Planetary Sciences, Terra Scientific Publishing Company, Tokyo, p. 37-42.

Churkin, M., Jr., and Carter, C., 1979, Collision-deformed paleozoic continental margin in Alaska -- a foundation for microplate accretion (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 3, p. 72.

Churkin, M., Jr., Carter, C., and Trexler, J. H., Jr., 1980, Collision-deformed Paleozoic continental margin of Alaska -- foundation for microplate accretion: Geological Society of America Bulletin, Part 1, v. 91, no. 11, p. 648-654.

Churkin, M., Jr., and Eberlein, G. D., 1977, Correlation of the rocks of southeastern Alaska with other parts of the Cordillera, in Blean, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1976: U.S. Geological Survey Circular 751-B, p. B69-B72.

Churkin, M., Jr., and Nokleberg, W. J., 1979, Collision-deformed paleozoic continental margin, western Brooks Range, Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 7, p. 401.

Churkin, M., Jr., and Nokleberg, W. J., 1980a, Reply on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 356-357.

Churkin, M., Jr., and Nokleberg, W. J., 1980b, Reply on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 359.

Cobb, E. H., 1973, Synopsis of the mineral resources and geology of Alaska: U.S. Geological Survey unpublished report, 95.

Cobb, E. H., 1978, Summary of references to mineral occurrences (other than mineral fuels and construction materials) in the Afognak, Karluk, Kodiak, and Trinity Islands quadrangles, Alaska: U.S. Geological Survey Open-File Report 79-860, 47 p.

Collins, K. M., and Stadnychenko, A., 1981, Gulf of Alaska and lower Cook Inlet summary report: U.S. Geological Survey Open-File Report 81-607, 49 p.

Connelly, W. R., 1976, Mesozoic geology of the Kodiak Islands and its bearing on the tectonics of southern Alaska: unpublished PhD dissertation, University of California, Santa Cruz, California, 196 p., 2 sheets.

Connelly, W. R., and Moore, J. C., 1979, Geologic map of the northwest side of the Kodiak and adjacent islands, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1057, 2 sheets, scale 1:63,360.

Conwell, C. N., and Triplehorn, D. M., 1976, High-quality coal near Point Hope, northwestern Alaska, in Short notes on Alaskan geology -- 1976: Alaska Division of Geology and Geophysics Geologic Report 51, p. 31-35.

Cony, P. J., Jones, D. L., and Monger, J. W. H., 1980, Cordilleran suspect terranes: Nature, v. 288, no. 5789, p. 329-333.

Coonrad, W. L., 1957, Geologic reconnaissance in the Yukon-Kuskokwim Delta region, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-223, 1 sheet, scale 1:500,000.

Cooper, A. K., 1977a, Marine geophysical investigation in the Bering Sea basin, in Blean, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1976: U.S. Geological Survey Circular 751-B, p. B98-B100.

Cooper, A. K., 1977b, Heat flow and organic gas measurements from the Aleutian Basin, Bering Sea, in Johnson, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1977: U.S. Geological Survey Circular 772-B, p. B92-B94.

Cooper, A. K., 1978, Hydrocarbon prospects for the frontier abyssal areas of the Bering Sea: Oil and Gas Journal, v. 76, no. 43, p. 196-201.

Cooper, A. K., 1979, Evolution of Unmak Plateau, Bering Sea (abs.): EOS, v. 60, no. 18, p. 390.

Churkin, M., Jr., and Nokleberg, W. J., 1980c, Reply on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 362-364.

Churkin, M., Jr., Nokleberg, W. J., and Huie, C., 1979, Collision-deformed Paleozoic continental margin, western Brooks Range, Alaska: Geology, v. 7, no. 8, p. 379-383.

Churkin, M., Jr., and Trexler, J. H., Jr., 1979, Comment on 'the Siberian connection -- a case for Precambrian separation of the North American and Siberian cratons': Geology, v. 7, no. 11, p. 467-469.

Churkin, M., Jr., and Trexler, J. H., Jr., 1981, Continental plates and accreted oceanic terranes in the Arctic, in Nairn, A. E. M., Churkin, M., Jr., and Stehli, F. G., eds., Ocean Basins and Margins, v. 5, The Arctic Ocean: New York, Plenum Press, p. 1-20.

Claypool, G. E., 1986, Petroleum geochemistry, in Magoon, L. B., ed., Geologic studies of the Lower Cook Inlet COST No. 1 Well, Alaska Outer Continental Shelf: U.S. Geological Survey Bulletin 1596, p. 33-39.

Claypool, G. E., and Magoon, L. B., 1980, Vitrinite reflectance and C1-C7 hydrocarbon data for Kugrua No. 1 well, North Slope, Alaska: U.S. Geological Survey Oil and Gas Investigations Chart OC-101, 1 sheet.

Claypool, G. E., Threlkeld, C. N., and Magoon, L. B., 1980, Biogenic and thermogenic origins of natural gas in Cook Inlet basin, Alaska: American Association of Petroleum Geologists Bulletin, v. 64, no. 8, p. 1131-1139.

Coats, R. R., 1955a, Geology of northern Adak Island, Alaska: U.S. Geological Survey Bulletin 1028-C, p. 45-67.

Coats, R. R., 1955b, Geology of northern Kanaga Island, Alaska: U.S. Geological Survey Bulletin 1028-D, p. 69-81.

Coats, R. R., 1955c, Reconnaissance geology of some western Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028-E, p. 83-100.

Coats, R. R., 1955d, Geology reconnaissance of Gareloi Island, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028-J, p. 249-256.

Coats, R. R., 1955e, Geologic reconnaissance of Semisopochnoi Island, western Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028-O, p. 477-519.

Coats, R. R., Nelson, W. H., Lewis, R. Q., and Powers, H. A., 1955, Geologic reconnaissance of Kiska Island, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028-R, p. 563-581.

Cooper, A. K., Bailey, K. A., Howell, J. I., Marlow, M. S., and Scholl, D. W., 1976, Preliminary residual magnetic map of the Bering Sea Basin and the Kamchatka Peninsula: U.S. Geological Survey Miscellaneous Field Studies Map MF-715, 1 sheet, scale 1:2,500,000.

Cooper, A. K., Childs, J. R., Marlow, M. S., Rabinowitz, P. D., Scholl, D. W., and Ludwig, W. J., 1977, Preliminary isopach and structure contour maps of Bering Sea Basin: U.S. Geological Survey Miscellaneous Field Studies Map MF-907, 1 sheet, scale 1:4,019,138.

Cooper, A. K., McLean, H., and Marlow, M. S., 1985, Crustal structure of Bristol Bay region, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 69, no. 4, p. 659.

Cooper, A. K., and Marlow, M. S., 1979, Geologic and geophysical cruise across the outer Bering continental margin, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B132-B34.

Cooper, A. K., and Marlow, M. S., 1983, Preliminary results of geophysical and geological studies of the Bering Sea Shelf during 1982: U.S. Geological Survey Open-File Report 83-322, 8 p.

Cooper, A. K., and Marlow, M. S., 1984, Geophysical and geological studies of the Bering Sea shelf, in Reed, K. M., and Bartsch-Winkler, S., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1982: U.S. Geological Survey Circular 939, p. 123-127.

Cooper, A. K., Marlow, M. S., Parker, A. W., and Childs, J. R., 1979, Structure-contour map on acoustic basement in the Bering Sea: U.S. Geological Survey Miscellaneous Field Studies Map MF-1165, 1 sheet, scale 1:2,500,000.

Cooper, A. K., Marlow, M. S., and Scholl, D. W., 1979, Thick sediment accumulation beneath continental margin of outer Bering Sea (abs.): American Association of Petroleum Geologists Bulletin, v. 63, no. 3, p. 436.

Cooper, A. K., Marlow, M. S., and Scholl, D. W., 1980a, Prospective and future hydrocarbon provinces of Bering Sea, south of St. Lawrence Island (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 693-694.

Cooper, A. K., Marlow, M. S., and Scholl, D. W., 1980b, Multifold seismic data across outer Bering Sea continental margin (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 694.

Cooper, A. K., Marlow, M. S., and Vallier, T. L., 1984, Summary geologic report for the St. George Outer Continental Shelf (OCS) planning area, Bering Sea, Alaska: U.S. Geological Survey Open-File Report 84-418, 81 p.

Cooper, A. K., Scholl, D. W., Marlow, M. S., Childs, J. R., Redden, G. D., Kvenvolden, K. A., and Stevenson, A. J., 1979, Hydrocarbon potential of Aleutian basin, Bering Sea: American Association of Petroleum Geologists Bulletin, v. 63, no. 11, p. 2070-2087.

Cooper, A. K., Scholl, D. W., Marlow, M. S., et al., 1980, Hydrocarbon potential of Aleutian basin, Bering Sea (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 3, p. 439-440.

Cooper, A. K., Scholl, D. W., Vallier, T.L., and Scott, E.W., 1979, Resource report for the deep-water areas of proposed OCS Lease Sale No. 70, St. George Basin, Alaska: U.S. Geological Survey Open-File Report 80-246, 91 p.

Cox, D. P., Detra, D. E., and Detterman, R. L., 1981, Mineral resource maps, Chignik and Sutwik Island quadrangles, Alaska U.S. Geological Survey Miscellaneous Field Studies Map MF-1053-K, 2 sheets, scale 1:250,000.

Craig, J. D., Sherwood, K. W., and Johnson, P. P., 1985, Geologic report for the Beaufort Sea Planning Area, Alaska -- regional geology, petroleum geology, environmental geology: U.S. Department of the Interior, Minerals Management Service, OCS Report MMS 85-0111, 192 p., 11 sheets.

Crane, R. C., 1980, Comment on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 354

Crick, R. W., 1971, Potential petroleum reserves, Cook Inlet, Alaska, in Cram, I. H., ed., Future petroleum provinces of the United States -- their geology and potential: American Association of Petroleum Geologists Memoir 15, p. 109-119.

Curray, J. R., 1977, Modes of emplacement of prospective hydrocarbon reservoir rocks of the outer continental margin environment, in Curray, J. R., Dickinson, W. R., Dow, W. G., Emery, K. O., Seely, D. R., Vail, P. R., and Yarborough, H., Geology of continental margins: American Association of Petroleum Geologists Education Course Note Series No. 5, p. E1-E14.

Davies, J. N., and Bond, G., 1980, Transverse structural features, displaced terranes and their relation to rupture zones of great earthquakes along the Alaska-Aleutian plate boundary (abs.): EOS, v. 61, no. 17, p. 292.

Decker, J., Nilsen, T. H., and Karl, S., 1979, Turbidite facies in the Sitka Graywacke, southeastern Alaska, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B125-B129.

Decker, J., and Johnson, B. R., 1981, The nature and position of the Border Ranges fault on Chichagof Island, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B102-B104.

Decker, J., Wilson, F. H., and Turner, D. L., 1980, Mid-Cretaceous subduction event in southeastern Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 12, no. 3, p. 103.

Detra, D. E., Detterman, R. L., Cox, D. P., Wilson, F. H., and Theodore, T. G., 1982, Reconnaissance geochemical studies in the Bristol Bay, Ugashik, and Karluk quadrangles, Alaska, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 87-88.

Detterman, R. L., 1973, Mesozoic sequence in Arctic Alaska, in Pitche, M. G., ed., Arctic geology -- proceedings of the second international symposium on arctic geology, February 1-4, 1971, San Francisco, California: American Association of Petroleum Geologists Memoir 19, Tulsa, Oklahoma, p. 376-387.

Detterman, R. L., 1977, Interpretation of depositional environments in the Chignik Formation, Alaska Peninsula, in Johnson, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1977: U.S. Geological Survey Circular 772-B, p. B62-B63.

Detterman, R. L., Case, J. E., and Yount, E. M., 1984, Onshore energy resources, Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1053-L, 2 sheets, scale 1:250,000.

Detterman, R. L., and Hartsock, J. K., 1966, Geology of the Iniskin-Tuxedni region, Alaska: U.S. Geological Survey Professional Paper 512, 78 p., 6 plates, scale 1:63,360.

Detterman, R. L., and Miller, J. W., 1985, Kaguyak Formation - an Upper Cretaceous flysch deposit, in Bartsch-Winkler, S., and Reed, K. M., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1983: U.S. Geological Survey Circular 945, p. 49-51.

Detterman, R. L., Miller, J. W., and Case, J. E., 1985, Megafossil locality map, checklists, and pre-Quaternary stratigraphic sections of Ugashik, Bristol Bay, and part of Karluk quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1539-B, 3 sheets, scale 1:250,000.

Detterman, R. L., Miller, T. P., Yount, M. E., and Wilson, F. H., 1981a, Geologic map of the Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1229, 1 sheet, scale 1:250,000.

Detterman, R. L., Miller, T. P., Yount, M. E., and Wilson, F. H., 1981b, Quaternary geologic map of the Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1292, 1 sheet, scale 1:250,000.

Detterman, R. L., and Reed, B. L., 1980, Stratigraphy, structure, and economic geology of the Iliamna quadrangle, Alaska: U.S. Geological Survey Bulletin 1368-B, p. B1-B85.

Detterman, R. L., Wilson, F. H., Yount, M. E., and Miller, T. P., 1987, Quaternary geologic map of the Ugashik, Bristol Bay, and western part of Karluk quadrangles, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1801, 1 sheet, scale 1:250,000.

Detterman, R. L., Yount, M. E., and Case, J. E., 1981, Megafossil localities, checklists, and stratigraphic sections, Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1053-N, 2 sheets, scale 1:250,000.

Dickinson, W. R., and Yarborough, H., 1976, Plate tectonics and hydrocarbon accumulation: American Association of Petroleum Geologists Education Course Note Series No. 5, 201 p.

Dumoulin, J. A., and Till, A. B., 1985, Seacliff exposures of metamorphic carbonate and schist, northern Seward Peninsula, in Bartsch-Winkler, S., and Reed, K. M., eds., United States Geological Survey in Alaska -- accomplishemnts during 1983: U.S. Geological Survey Circular 945, p. 18-22.

Dow, W. G., 1977, Petroleum source beds on continental slopes and rises, in Curray, J. R., Dickinson, W. R., Dow, W. G., Emery, K. O., Seely, D. R., Vail, P. R., and Yarborough, H., Geology of continental margins: American Association of Petroleum Geologists Education Course Note Series No. 5, p. D1-D37.

Dow, W. G., 1979, Petroleum source beds on continental slopes and rises, in Watkins, J. S., Montadert, L., and Dickerson, P. W., eds., Geological and geophysical investigations of continental margins: American Association of Petroleum Geologists Memoir 29, p. 423-442.

Drewes, H., Fraser, G. D., Snyder, G. L., and Barnett, H. F., Jr., 1955, Geology of Unalaska Island and adjacent insular shelf, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028-S, p. 583-676.

Dutro, J. T., Jr., 1980, Comment on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 355-356.

Dutro, J. T., Jr., 1981, Geology of Alaska bordering the Arctic Ocean, in Nairn, A. E. M., Churkin, M., Jr., and Stehli, R. G., eds., Ocean basins and margins, v. 5, The Arctic Ocean: Plenum Press, New York, p. 1-20.

Dutro, J. T., Jr., Armstrong, A. K., Douglass, R. C., and Mamet, B. L., 1981, Carboniferous biostratigraphy, southeastern Alaska, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B94-B96.

Egbert, R. M., and Magoon, L. B., 1981, Petrography, provenance, and tectonic significance of Middle and Upper Jurassic sandstone from Tuxedni Bay, Cook Inlet, Alaska, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B86-B88.

Egbert, R. M., 1986, Petrography, provenance, and tectonic significance of Middle and Upper Jurassic sandstone from Tuxedni Bay, in Magoon, L. B., ed., Geologic studies of the Lower Cook Inlet COST No. 1 Well, Alaska Outer Continental Shelf: U.S. Geological Survey Bulletin 1596, p. 61-63.

Egiazarov, B. K., Ermakov, B. V., Anikeyeva, L. I., Kopylova, T. N., Andreyev, S. I., Itsiksen, M. I., and Berger, V. I., 1976, Tectonics of continental and oceanic structures of North Pacific mobile belt -- summary (abs.), in Halbouty, M. T., Maher, J. C., and Lian, H. M., eds., Circum-Pacific energy and mineral resources: American Association of Petroleum Geologists Memoir 25, p. 62.

Ehm, A., 1983, Oil and gas basins map of Alaska: Alaska Division of Geological and Geophysical Surveys, Special Report 32, 1 sheet, scale 1:2,500,000.

Eittreim, S., Grantz, A., and Whitney, O. T., 1977, Tectonic imprints on sedimentary deposits in Hope basin, in Blean, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1976: U.S. Geological Survey Circular 751-B, p. B100-B103.

Eittreim, S., Grantz, A., and Whitney, O. T., 1979, Cenozoic sedimentation and tectonics of Hope basin, southern Chukchi Sea, in Sisson, A., ed., The relationship of plate tectonics to Alaskan geology and resources, 1977 symposium proceedings: AGS, Anchorage, Alaska, p. B1-B11.

Ellersieck, I. F., Jansons, U., Mayfield, C. F., and Tailleur, I. L., 1982, The Story Creek and Whoopee Creek lead-zinc-silver occurrences, western Brooks Range, Alaska, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 35-38.

Fisher, M. A., 1978, Structure and tectonic setting of continental shelf southwest of Kodiak Island, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 62, no. 3, p. 513.

Fisher, M. A., 1979, Structure and tectonic setting of continental shelf southwest of Kodiak Island, Alaska: American Association of Petroleum Geologists Bulletin, v. 63, no. 3, p. 301-310.

Fisher, M. A., 1980a, Structure and hydrocarbon potential of Kodiak shelf, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 706-707.

Fisher, M. A., 1980b, Petroleum geology of Kodiak Shelf, Alaska: American Association of Petroleum Geologists Bulletin, v. 64, no. 8, p. 1140-1157.

Fisher, M. A., 1981, Location of the Border Ranges fault southwest of Kodiak Island, Alaska: Geological Society of America Bulletin, Part 1, v. 92, no. 1, p. 19-30.

Fischer, J. M., 1981, Carbon contents of Navarin Basin sediments, in Carlson, P. R., and Karl, H. A., eds., Seafloor geologic hazards, sedimentology, and bathymetry -- Navarin Basin province, northwestern Bering Sea: U.S. Geological Survey Open-File Report 81-1217, p. 44-57.

Fisher, M. A., 1982a, Petroleum geology of Norton basin, Alaska: American Association of Petroleum Geologists Bulletin, v. 66, no. 3, p. 286-301.

Fisher, M. A., 1982b, Preliminary interpretation of geophysical data over the projected offshore location of the Kaltag fault, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 136-139.

Fisher, M. A., Childs, J. R., and Magistrale, H. W., 1982, Free-air gravity map, Norton Basin, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1460, 1 sheet, scale 1:250,000.

Fisher, M. A., and Holmes, M. L., 1980, Large-scale structure of deep strata beneath Kodiak shelf, Alaska: Geological Society of America Bulletin, Part 1, v. 91, no. 4, p. 218-224.

Fisher, M. A., Holmes, M. L., and Patton, W. W., Jr., 1981, Preliminary interpretation of the geologic structure beneath the northern Bering Sea shelf, including Norton Basin, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B118-B121.

Fisher, M. A., and Magoon, L. B., 1978, Geologic framework of lower Cook Inlet, Alaska: American Association of Petroleum Geologists Bulletin, v. 62, no. 3, p. 373-402.

Fisher, M. A., Moore, G. W., von Huene, R., and McClellan, P. H., 1981, Map of marine magnetic data from Shelikof Strait to Sutwik Island, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1227, 1 sheet, scale 1:500,000.

Fisher, M. A., Patton, W. W., Jr., and Holmes, M. L., 1981, Geology and petroleum potential of the Norton Basin area, Alaska: U.S. Geological Survey Open-File Report 81-1316, 51 p., 5 tables, 28 figures.

Fisher, M. A., Patton, W. W., Jr., and Holmes, M. L., 1982, Geology and petroleum potential of Alaska's Norton basin area: Oil and Gas Journal, v. 80, no. 18, p. 343-371.

Fisher, M. A., Patton, W. W., Jr., Thor, D. R., Holmes, M. L., Scott, E. W., Nelson, C. H., and Wilson, C. L., 1979a, The Norton basin of Alaska: Oil and Gas Journal, v. 77, no. 21, p. 96-98.

Fisher, M. A., Patton, W. W., Jr., Thor, D. R., Holmes, M. L., Scott, E. W., Nelson, C. H., and Wilson, C. L., 1979b, Resource report for proposed OCS lease sale 57 -- Norton Basin, Alaska: U.S. Geological Survey Open-File Report 79-720, 75 p.

Fisher, M. A., and von Huene, R., 1980, Structure of upper Cenozoic strata beneath Kodiak Shelf, Alaska: American Association of Petroleum Geologists Bulletin, v. 64, no. 7, p. 1014-1033.

Fisher, M. A., and von Huene, R., 1982, Map showing the geologic structure of the continental shelf southeast and southwest of Kodiak Island, Alaska from 24-fold seismic data: U.S. Geological Survey Miscellaneous Field Studies Map MF-1457, 1 sheet, scale 1:500,000.

Fraser, G. D., and Barnett, H. F., 1955, Geology of the Delarof and westernmost Andreanof Islands, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028-I, p. 211-248.

Fraser, G. D., and Snyder, G. L., 1955, Geology of southern Adak Island and Kagalaska Island, Alaska: U.S. Geological Survey Bulletin 1028-M, p. 371-408.

Gard, L. M., Jr., 1980, The Pleistocene geology of Amchitka Island, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1478, 38 p.

Gates, G. O., Grantz, A., and Patton, W. W., Jr., 1968, Geology and natural gas and oil resources of Alaska, in Natural gases of North America, pt. 1: American Association of Petroleum Geologists Memoir 9, v. 1, p. 3-48.

Gates, G. O., Powers, H. A., and Wilcox, R. E., 1955, Geology of the Near Islands, Alaska: U.S. Geological Survey Bulletin 1028-U, p. 709-822.

Gehrels, G. E., Saleeby, J. B., and Berg, H. C., 1984, Geologic framework of Paleozoic rocks on southern Annete and Hotspur Islands, southern Alexander terrane, in Coonrad, W. L., and Elliott, R. L., , eds., The United States Geological Survey in Alaska -- accomplishemnts during 1981: U.S. Geological Survey Circular 868, p. 113-115.

Gehrels, G. E., Saleeby, J. B., and Berg, H. C., 1984, Progress in geologic studies of southern Prince of Wales Island, southern Alexander Terrane, southeast Alaska, in Reed, K. M., and Bartsch-Winkler, S., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1982: U.S. Geological Survey Circular 939, p. 102-105.

Gemuts, I., Puchner, C. C., and Steffel, C. I., 1983, Regional geology and tectonic history of western Alaska, in Western Alaska geology and resource potential, proceedings of the 1982 symposium: Journal of the AGS, v. 3, p. 67-85.

Gibson, C., Seidlitz, A., Evans, D., and Borkoski, J., 1988, Oil and gas assessment of the Yukon Delta and Togiak National Wildlife Refuges: U.S. Department of the Interior, Bureau of Land Management, unpublished report prepared for the U.S. Fish and Wildlife Service, 94 p., 6 sheets.

Golan-Bac, M., and Kvenvolden, K. A., 1984, Hydrocarbon gases in sediments from Navarin Basin, Bering Sea -- results from 1982 field season: U.S. Geological Survey Open-File Report 84-97, 11 p.

Grantz, A., Barnes, P. W., Dinter, D. A., Lynch, M. B., Reimnitz, E., and Scott, E. W., 1980, Geologic framework, hydrocarbon potential, environmental conditions, and anticipated technology for exploration and development of the Beaufort Shelf north of Alaska: U.S. GeologicalsSurvey Open-File Report 80-94, 42 p.

Grantz, A., Boucher, G., and Whitney, O. T., 1976, Possible solid gas hydrate and natural gas deposits beneath the continental slope of the Beaufort Sea, in Cobb, E. H., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1975: U.S. Geological Survey Circular 733, p. 17.

Grantz, A., Dinter, D. A., and Biswas, N. N., 1983, Map, cross sections, and chart showing Late Quaternary faults, folds, and earthquake epicenters on the Alaskan Beaufort Shelf: U.S. Geological Survey Miscellaneous Investigations Series Map I-1182-C, 7 p., 3 sheets, scale 1:500,000 at latitude 72°00'N.

Grantz, A., Dinter, D. A., Hill, E. R., Hunter, R. E., May, S. D., McMullin, R. H., and Phillips, R. L., 1982, Geologic framework, hydrocarbon potential, and environmental conditions for exploration and development of proposed oil and gas lease sale 85 in the central and northern Chukchi Sea -- a summary report: U.S. Geological Survey Open-File Report 82-1053, 84 p.

Grantz, A., Dinter, D. A., Hill, E. R., May, S. D., McMullin, R. H., Phillips, R. L., and Reimnitz, E., 1982, Geologic framework, hydrocarbon potential, and environmental conditions for exploration and development of proposed oil and gas lease sale 87 in the Beaufort and northeast Chukchi Seas -- a summary report: U.S. Geological Survey Open-File Report 82-482, 71 p.

Grantz, A., Eittreim, S., and Whitney, O. T., 1981, Geology and physiography of the continental margin north of Alaska and implications for the origin of the Canada Basin, in Nairn, A. E. M., Churkin, M., Jr., and Stehlim F. G., eds., Ocean basins and margins, v. 5, The Arctic Ocean: Plenum Press, New York, p. 439-492.

Grantz, A., and Kirschner, C. E., 1975, Tectonic framework of petroliferous rocks in Alaska: U.S. Geological Survey Open-File Report 75-149, 29 p., 14 figures.

Grantz, A., and Kirschner, C. E., 1976, Tectonic framework of petroliferous rocks in Alaska, in Halbouty, M. T., Maher, J. C., and Lian, H. M., eds., Circum-Pacific energy and mineral resources: American Association of Petroleum Geologists Memoir 25, p. 291-307.

Grantz, A., and May, S. D., 1983a, Geologic framework and petroleum potential of United States Chukchi shelf north of Point Hope, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 67, no. 3, p. 474.

Grantz, A., and May, S. D., 1983b, Rifting history and structural development of the continental margin north of Alaska in Watkins, J. S., and Drake, C. L., eds., Studies in continental margin geology: American Association of Petroleum Geologists Memoir No. 34, p. 77-100.

Grantz, A., and May, S. D., 1984, Summary geologic report for Barrow Arch Outer Continental Shelf (OCS) planning area, Chukchi Sea, Alaska: U.S. Geological Survey Open-File Report 84-395, 40 p.

Grantz, A., Wolf, S. C., Breslau, L., Johnson, T. C., and Hanna, W. F., 1970, Reconnaissance geology of the Chukchi Sea as determined by acoustic and magnetic profiling, *in* Adkison, W. L., and Brosge, M. M., eds., Proceedings of the geological seminar on the North Slope of Alaska: Pacific Section, American Association of Petroleum Geologists, Los Angeles, California, F1-F28.

Green, A. R., 1977, Evolution of continental margin basins (abs.), *in* Curray, J. R., Dickinson, W. R., Dow, W. G., Emery, K. O., Seely, D. R., Vail, P. R., and Yarborough, H., Geology of continental margins: American Association of Petroleum Geologists Education Course Note Series No. 5, p. G1.

Griscom, A., 1978, Aeromagnetic interpretation of the Goodnews and Hagemeister Island quadrangles region, southwestern Alaska: U.S. Geological Survey Open-File Report 78-9-C, 20 p., 2 sheets, scale 1:250,000.

Gromme, C. S., Eberlein, G. D., and Churkin, M., Jr., 1980, Paleozoic paleomagnetism and northward drift of the Alexander Terrane, southeastern Alaska: Journal of Geophysical Research, v. 85, no. B10, p. 5281-5296.

Gromme, C. S., and Hillhouse, J. W., 1981, Paleomagnetic evidence for northward movement of the Chugach terrane, southern and southeastern Alaska, *in* Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B70-B72.

Grybeck, D., Brew, D. A., Johnson, B. R., and Nutt, C. J., 1977, Ultramafic rocks in part of the Coast Range batholithic complex, southeastern Alaska, *in* Blean, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1976: U.S. Geological Survey Circular 751-B, p. B82-B84.

Gryc, G., 1971, Summary of potential petroleum resources of region 1 (Alaska and Hawaii) -- Alaska, *in* Cram, I. H., ed., Future petroleum provinces of the United States -- their geology and potential: American Association of Petroleum Geologists Memoir 15, p. 55-67.

Gryc, G., 1982, Petroleum exploration in the National Petroleum Reserve in Alaska, *in* U.S. Geological Survey activities, fiscal year 1981: U.S. Geological Survey Circular 875, p. 14-21.

Hackett, S. W., 1976, Speculative tectonic evolution of the Cenozoic Shelikof Trough, south-central Alaska, *in* Short notes on Alaskan geology -- 1976: Alaska Division of Geology and Geophysics Geologic Report 51, p. 13-14.

Hammond, R. D., and Gaither, J. R., 1982, Anomalous seismic character -- Bering Sea (abs.): American Association of Petroleum Geologists Bulletin, v. 66, no. 5, p. 576-577.

Hampton, M. A., 1982, Synthesis report -- environmental geology of Kodiak Shelf, Alaska: U.S. Geological Survey Open-File Report 82-59, 76 p.

Hampton, M. A., 1983, Geotechnical framework study of Shelikof Strait, Alaska: U.S. Geological Survey Open-File Report 83-200, 121 p.

Hanley, P. T., and Wade, W. W., 1981, Bering basins show good potential: Offshore, v. 41, no. 4, p. 121-127.

Hanley, P. T., and Wade, W. W., 1982, Developing the petroleum resources of Bering Sea -- technology, economics, and geology (abs.): American Association of Petroleum Geologists Bulletin, v. 66, no. 7, p. 970.

Hanley, P. T., Wade, W. W., and Feldman, M. L., 1981, Alaska OCS -- game of giant fields: Offshore, v. 41, no. 4, p. 105-110.

Harris, A. G., Ellersieck, I. F., Mayfield, C. F., and Tailleur, I. L., 1983, Thermal maturation values (conodont color alteration indices) for Paleozoic and Triassic rocks, Chandler Lake, De Long Mountains, Howard Pass, Killik River, Misheguk Mountain, and Point Hope quadrangles, northwest Alaska, and subsurface NPRA: U.S. Geological Survey Open-File Report 83-505, 15 p.

Hastings, D. S., Robinson, A. G., and Robinson, N. M., Jr., 1983, Stratigraphy, depositional history, and reservoir potential of Cretaceous and early Tertiary rocks of lower Cook Inlet, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 67, no. 3, p. 480.

Hatten, C. W., 1971, Petroleum potential of Bristol Bay basin, Alaska, in Cram, I. H., ed., Future petroleum provinces of the United States -- their geology and potential: American Association of Petroleum Geologists Memoir 15, p. 105-108.

Healey, D. L., and Kibler, J. D., 1976, Complete bouguer and free-air gravity anomaly maps of the Delarof Islands and Tanaga Island, Alaska: U.S. Geological Survey Geophysical Investigations Map GP-908, 1 sheet, scale 1:250,000.

Hedberg, H. D., and Moody, J. D., 1977, Petroleum prospects of continental slopes and rises (abs.), in Curray, J. R., Dickinson, W. R., Dow, W. G., Emery, K. O., Seely, D. R., Vail, P. R., and Yarborough, H., Geology of continental margins: American Association of Petroleum Geologists Education Course Note Series No. 5, p. G9-G10.

Hein, J. R., and McLean, H., 1977, Paleogene sedimentary and volcanogenic rocks form Adak Island, central Aleutian Islands, Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 9, no. 4, p. 433.

Hein, J. R., and McLean, H., 1980, Paleogene sedimentary and volcanogenic rocks from Adak Island, central Aleutian Island, Alaska: U.S. Geological Survey Professional Paper 1126-E, p. E1-E16.

Hein, J. R., McLean, H., and Vallier, T., 1984, Reconnaissance geology of southern Atka Island, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1609, 19 p.

Helwig, J., 1980, Stratigraphy and structure of early Tertiary Orca Group, Prince William Sound, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 722.

Helwig, J., and Emmet, P., 1981, Structure of the early Tertiary Orca Group in Prince William Sound and some implications for the plate tectonic history of southern Alaska: Journal of the Alaska Geological Society, v. 1., p. 12-35.

Hill, M., and Whelan, J., 1979, Involvement of sediment anatexis in the genesis of early Tertiary granodiorite and granite, southwestern Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 7, p. 444.

Hillhouse, J. W., and Gromme, C. S., 1980, Paleomagnetism of the Triassic Hound Island Volcanics, Alexander Terrane, southeastern Alaska: Journal of Geophysical Research, v. 85, no. B5, p. 2594-2602.

Hoare, J. M., and Condon, W. H., 1966, Geologic map of the Kwiguk and Black quadrangles, western Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-469, 7 p., 1 sheet, scale 1:250,000.

Hoare, J. M., and Condon, W. H., 1968, Geologic map of the Hooper Bay quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-523, 4 p., 1 sheet, scale 1:250,000.

Hoare, J. M., and Condon, W. H., 1971, Geologic map of the St. Michael quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-682, 5 p., 1 sheet, scale 1:250,000.

Hoare, J. M., and Coonrad, W. L., 1959, Geology of the Bethel quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-285, 1 sheet, scale 1:250,00.

Hoare, J. M., and Coonrad, W. L., 1961, Geologic map of the Hagemeister Island quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-321, 1 sheet, scale 1:250,000.

Hoare, J. M., and Coonrad, W. L., 1961, Geologic map of the Goodnews quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-339, 1 sheet, scale 1:250,000.

Hoare, J. M., and Coonrad, W. L., 1980, The Togiak Basalt, a new formation in southwestern Alaska: U.S. Geological Survey Bulletin 1482-C, p. C1-C11.

Hoare, J. M., and Coonrad, W. L., 1983, Graywacke of Buchia Ridge and correlative Lower Cretaceous rocks in the Goodnews Bay and Bethel quadrangles, southwestern Alaska: U.S. Geological Survey Bulletin 1529-C, 17 p.

Hoare, J. M., Coonrad, W. L., and McCoy, S., 1983, Summit Island Formation, a new Upper Cretaceous formation in southwestern Alaska: U.S. Geological Survey Bulletin 1529-B, p. B1-B18.

Holmes, M. L., and Cline, J. D., 1977, Acoustic anomalies and seeping gas in Norton Basin, Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 9, no. 7, p. 1022.

Holmes, M. L., and Fisher, M. A., 1979, Sonobouy refraction measurements for Norton Basin, northern Bering Sea (abs.): American Association of Petroleum Geologists Bulletin, v. 63, no. 3, p. 468.

Hoose, P. J., and Ashenfelter, K. H., 1983, Shallow geology of north Aleutian shelf area, Bering Sea, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 67, no. 3, p. 485.

House, L., Sykes, L. R., Davies, J. N., and Jacob, K. H., 1980, Evidence for a possible seismic gap near Unalaska Island in the eastern Aleutians, Alaska (abs.): EOS, v. 61, no. 17, p. 292.

Hudson, T., 1986, Plutonism and provenance -- implications for sandstone compositions, in Magoon, L. B., ed., Geologic studies of the Lower Cook Inlet COST No. 1 Well, Alaska Outer Continental Shelf: U.S. Geological Survey Bulletin 1596, p. 55-60.

Hudson, T., Plafker, G., and Dixon, K., 1982, Horizontal offset history of the Chatham Strait fault, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 128-132.

Huffman, A. C., 1979, Stratigraphy and petrography of a measured section on the south limb of Barabara Syncline, North Slope, Alaska, in Ahlbrandt, T. S., ed., Preliminary geologic, petrologic, and paleontologic results of the study of Nanushuk Group rocks, North Slope, Alaska: U.S. Geological Survey Circular 794, p. 77-88.

Huffman, A. C., and Ahlbrandt, T. S., 1979, The Cretaceous Nanushuk Group of the western and central North Slope, Alaska, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B46-B50.

Imlay, R. W., and Detterman, R. L., 1977, Some Lower and Middle Jurassic beds in Puale Bay-Alinchak Bay area, Alaska Peninsula: American Association of Petroleum Geologists Bulletin, v. 61, no. 4, p. 607.

Johnson, B. R., Forn, C. L., Hoffman, J. D., Brew, D. A., and Nutt, C. J., 1977, Geochemical sampling of stream sediments, Tracy Arm, southeastern Alaska, in Blean, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1976: U.S. Geological Survey Circular 751-B, p. B80-B82.

Johnson, B. R., and Karl, S. M., 1982, Reconnaissance geologic map of the western Chichagof and Yakobi Islands Wilderness Study area, southeastern Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1476-A, 1 sheet, scale 1:125,000.

Johnson, B. R., and Karl, S. M., 1985, Geologic map of western Chichagof and Yakobi Islands, southeastern Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1506, 15 p., 1 sheet, scale 1:125,000.

Johnson, K. A., 1981, Clay mineral distribution in Navarin Basin, Bering Sea, in Carlson, P. R., and Karl, H. A., eds., Seafloor geologic hazards, sedimentology, and bathymetry -- Navarin Basin province, northwestern Bering Sea: U.S. Geological Survey Open-File Report 81-1217, p. 34-43.

Jones, B. C., 1980, Developments in Alaska in 1979: American Association of Petroleum Geologists Bulletin, v. 64, no. 9, p. 1345-1353.

Jones, B. K., and Forbes, R. B., 1976, Geology and mineral resources of the St. Lawrence Island Reserve, Alaska: Geophysical Institute, University of Alaska, for U.S. Department of the Interior, Bureau of Indian Affairs.

Jones, D. L., Berg, H. C., Coney, P., and Harris, A., 1981, Structural and stratigraphic significance of Upper Devonian and Mississippian fossils from the Cannery Formation, Kupreanof Island, southeastern Alaska, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B109-B112.

Jones, D. L., Howell, D. G., Coney, P. J., and Monger, J. W. H., 1983, Recognition, character, and analysis of tectonographic terranes in western North America, in Hashimoto, M., and Uyeda, S., eds., Accretion tectonics in the circum-Pacific region: Advances in Earth and Planetary Sciences, Terra Scientific Publishing Company, Tokyo, p. 21-35.

Jones, D. L., and Silberling, N. J., 1979a, Mesozoic accretionary tectonics of southern and central Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 7, p. 452.

Jones, D. L., and Silberling, N. J., 1979b, Mesozoic stratigraphy -- the key to tectonic analysis of southern and central Alaska: U.S. Geological Survey Open-File Report 79-1200, 39 p.

Jones, D. L., Silberling, N. J., Berg, H. C., and Plafker, G., 1982, Map showing tectonostratigraphic terranes of Alaska, columnar sections, and summary description of terranes: U.S. Geological Survey Open-File Report 81-792, 20 p., 2 sheets.

Jones, D. L., Silberling, N. J., Coney, P. J., and Plafker, G., 1987, Lithotectonic terrane map of Alaska (west of the 141st meridian): U.S. Geological Survey Miscellaneous Field Studies Map MF-1874-A, 1 sheet, scale 1:2,500,000.

Jones, P. B., 1980, Evidence from Canada and Alaska on plate tectonic evolution of the Arctic Ocean Basin: Nature, v. 285, no. 5762, p. 215-217.

Kachadoorian, R., and Crory, F. E., 1984, Engineering geology studies in the National Petroleum Reserve, Alaska: U.S. Geological Survey Open-File Report 83-6, 37 p.

Karl, H. A., and Carlson, P. R., 1984, Surface and near-surface geology, Navarin basin province -- results of the 1980-81 field seasons: U.S. Geological Survey Open-File Report 84-89, 118 p.

Karl, H. A., Carlson, P. R., Fischer, J. M., Johnson, K. A., and Lamb, B., 1981, Textural variations and composition of bottom sediment, in Carlson, P. R., and Karl, H. A., eds., Seafloor geologic hazards, sedimentology, and bathymetry -- Navarin Basin province, northwestern Bering Sea: U.S. Geological Survey Open-File Report 81-1217, p. 28-33.

Karl, S. M., Decker, J. E., and Johnson, B. R., 1982, Discrimination of Wrangellia and the Chugach terrane in the Kelp Bay Group on Chichagof and Baranof Islands, southeastern Alaska, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 124-128.

Karl, S. M., Decker, J., and Jones, D. L., 1979, Early Cretaceous radiolarians from the McHugh Complex, south-central Alaska, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B88-B90.

Kelley, J. S., 1977, Study of heavy minerals for Tertiary rocks at Capps Glacier and adjacent areas, southern Alaska: U.S. Geological Survey Open-File Report 77-502, 11 p., 2 sheets.

Kennedy, G. C., and Waldron, H. H., 1955, Geology of Pavlof volcano and vicinity, Alaska: U.S. Geological Survey Bulletin 1028-A, p. 1-19.

Khain, V. E., Seslavinsky, K. B., 1979, Comment on 'the Siberian connection -- a case for Precambrian separation of the North American and Siberian cratons': Geology, v. 7, no. 11, p. 466-467.

Kienle, J., Swanson, S. E., and Pulpan, H., 1983, Magmatism and subduction in the eastern Aleutian arc, in Shimozuru, D., and Yokoyama, I., eds., Arc volcanism -- physics and tectonics: Advances in Earth and Planetary Sciences, Terra Scientific Publishing Company, Tokyo, p. 191-224.

Kienle, J., and Turner, D. L., 1976, The Shumagin batholith -- a Paleocene magmatic arc?, in Short notes on Alaskan geology -- 1976: Alaska Division of Geology and Geophysics Geologic Report 51, p. 9-11.

Kvenvolden, K. A., and Claypool, G. E., 1980, Origin of gasoline-range hydrocarbons and their migration by solution in carbon dioxide in Norton Basin, Alaska: American Association of Petroleum Geologists Bulletin, v. 64, no. 7, p. 1078-1086.

Kvenvolden, K. A., Rapp, J. B., and Nelson, H., 1978, Hydrocarbons of low molecular weight in sediments from Norton Sound, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 62, no. 3., p. 534.

Kvenvolden, K. A., and Redden, G. D., 1977, Low molecular weight hydrocarbons in sediments of the southern Bering Shelf (abs.): Abstracts with Programs, Geological Society of America, v. 9, no. 4, p. 449.

Kvenvolden, K. A., Redden, G. D., and Carlson, P. R., 1977, Hydrocarbon gases in sediments of eastern Gulf of Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 61, no. 5, p. 806.

Kvenvolden, K. A., and von Huene, R., 1984., Potential for generation of natural gas in sediments of the convergent margin of the Aleutian Trench area: U.S. Geological Survey Open-File Report 84-404, 60 p.

Kvenvolden, K. A., Weliky, K., Nelson, H., and Des Marais, D. J., 1979, Submarine seep of carbon dioxide in Norton Sound, Alaska: Science, v. 205, no. 4412, p. 1264-1266.

Lankford, S. M., and Hill, J. M., 1979, Stratigraphy and depositional environment of the Dutch Harbor Member of the Unalaska Formation, Unalaska Island, Alaska: U.S. Geological Survey Bulletin 1457-B, p. B1-B14.

Lanphere, M. A., and Eberlein, G. D., 1977, Precambrian rocks of Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 9, no. 7, p. 1066.

Larson, J., and Olson, D. L., 1984, Hydrocarbon potential of Kotzebue Sound: U.S. Department of the Interior, Minerals Management Service unpublished report, 17 p., 1 figure.

Larsen, M. C., Nelson, C. H., and Thor, D. R., 1980, Geological, geochemical and geotechnical observations on the Bering Shelf, Alaska: U.S. Geological Survey Open-File Report 80-979, 488 p.

Lathram, E. H., 1973, Tectonic framework of northern and central Alaska, in Pitcher, M. G., ed., Arctic geology -- proceedings of the second international symposium on arctic geology, February 1-4, 1971, San Francisco, California: American Association of Petroleum Geologists Memoir 19, Tulsa, Oklahoma, p. 351-360.

Lattanzi, R. D., 1981, Planktonic foraminiferal biostratigraphy of Exxon Company USA wells drilled in the Gulf of Alaska during 1977 and 1978: Journal of the Alaska Geological Society, v. 1., p. 48-59.

Legg, G. W., 1983a, Geological report east Teshekpuk test well No. 1: Husky Oil NPR Operations, Inc.

Legg, G. W., 1983b, Geological report Kugrua test well No. 1: Husky Oil NPR Operations, Inc.

Legg, G. W., 1983c, Geological report Tunalik test well No. 1: Husky Oil NPR Operations, Inc.

Lewis, R. Q., Nelson, W. H, and Powers, H. A., 1955, Geology of Rat Island, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028-Q, p. 555-562.

Loney, R. A., Berg, H. C., Pomeroy, J. S., and Brew, D. A., 1963, Reconnaissance geologic map of Chichagof Island and northwestern Baranof Island, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-388, 7 p., 1 sheet, scale, 1:250,000.

Loney, R. A., Pomeroy, J. S., Brew, D. A., and Muffler, L. J. P., 1964, Reconnaissance geologic map of Baranof and Kruzof Islands, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-411, 1 sheet, scale 1:250,000.

Lyle, W. M., Morehouse, J. A., Palmer, I. F., Jr., and Bolm, J. G., 1979, Tertiary formations and associated Mesozoic rocks in the Alaska Peninsula area, Alaska, and their petroleum-reservoir and source-rock potential: Alaska Division of Geological and Geophysical Surveys Geologic Report 62, 65 p., 19 sheets, scale 1:250,000.

Lyle, W., Morehouse, J., Palmer, I. F., Bolm, J. G., Moore, G. W., and Nilsen, T. H., 197?, Tertiary formations in the Kodiak Island area, Alaska, and their petroleum reservoir and source-rock potential: Alaska Division of Geological Surveys, Alaska Open-File Report 114, 56 p.

Lyle, W. M., Palmer, I. F., Jr., Bolm, J. G., and Flett, T. O., 1982, Hydrocarbon reservoir and source-rock characteristics from selected areas of southwestern Alaska: Alaska Division of Geological and Geophysical Surveys Professional Report 77, 35 p., 7 sheets, scale 1:1,584,000.

McClellan, P. H., Arnal, R. E., and Barron, J. A., von Huene, R., Fisher, M. A., and Moore, G. W., 1980, Biostratigraphic results of dart-coring in the western Gulf of Alaska, and their tectonic implications: U.S. Geological Survey Open-File Report 80-63, 11 p., 1 table, 6 figures.

MacKevett, E. M., Jr., Brew, D. A., Hawley, C. C., Huff, L. C., and Smith, J.G., 1971, Mineral resources of Glacier Bay National Monument, Alaska: U.S. Geological Survey Professional Paper 632, 90 p., 12 sheets, scale varies.

McLean, H., 1977, Tertiary sedimentary rocks of the Alaska Peninsula between Pavlof Bay and False Pass; their geology and petroleum potential, in Johnson, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1977: U.S. Geological Survey Circular 772-B, p. B65-B66.

McLean, H., 1979a, Tertiary stratigraphy and petroleum potential of Cold Bay-False Pass area, Alaska Peninsula: American Association of Petroleum Geologists Bulletin, v. 63, no. 9, p. 1522-1526.

McLean, H., 1979b, Observations on the geology and petroleum potential on the Cold Bay-False Pass area, Alaska Peninsula: U.S. Geological Survey Open-File Report 79-1605, 34 p.

Magoon, L. B., 1986a, Stratigraphic units of the COST No. 1 well, in Magoon, L. B., ed., Geologic studies of the Lower Cook Inlet COST No. 1 Well, Alaska Outer Continental Shelf: U.S. Geological Survey Bulletin 1596, p. 17-22.

Magoon, L. B., 1986b, Present-day geothermal gradient, in Magoon, L. B., ed., Geologic studies of the Lower Cook Inlet COST No. 1 Well, Alaska Outer Continental Shelf: U.S. Geological Survey Bulletin 1596, p. 41-46.

Magoon, L. B., 1986c, Conclusions, in Magoon, L. B., ed., Geologic studies of the Lower Cook Inlet COST No. 1 Well, Alaska Outer Continental Shelf: U.S. Geological Survey Bulletin 1596, p. 91-93.

Magoon, L. B., Adkison, W. L., and Egbert, R. M., 1976, Map showing geology, wildcat wells, Tertiary plant fossil localities, K-Ar age dates, and petroleum operations, Cook Inlet area, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1019, 3 sheets, scale 1:250,000.

Magoon, L. B., Bouma, A. H., Fisher, M. A., Hampton, M. A., Scott, E. W., and Wilson, C. L., 1979, Resource report for proposed OCS sale No. 60, lower Cook Inlet-Shelikof Strait, Alaska: U.S. Geological Survey Open-File Report 79-600, 38 p.

Magoon, L. B., and Claypool, G. E., 1978, Petroleum geology of Cook Inlet basin, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 62, no. 7, p. 1225.

Magoon, L. B., and Claypool, G. E., 1979a, Hydrocarbon source potential of the Nanushuk Group and the Torok Formation, a preliminary report, in Ahlbrandt, T. S., ed., Preliminary geologic, petrologic, and paleontologic results of the study of Nanushuk Group rocks, North Slope, Alaska: U.S. Geological Survey Circular 794, p. 54-60.

Magoon, L. B., and Claypool, G. E., 1979b, Petroleum geology of Cook Inlet Basin, Alaska -- an exploration model: U.S. Geological Survey Open-File Report 79-548, 44 p.

Magoon, L. B., and Claypool, G. E., 1979c, Origin of Cook Inlet oil, in Sisson, A., ed., The relationship of plate tectonics to Alaskan geology and resources, proceedings of the sixth Alaska Geological Society symposium held April 4-6, 1977, at Anchorage, Alaska: Alaska Geological Society, Anchorage, Alaska, p. G1-G17.

Magoon, L. B., and Claypool, G. E., 1981, Petroleum geology of Cook Inlet basin -- an exploration model: American Association of Petroleum Geologists Bulletin, v. 65, no. 6, p. 1043-1061.

Magoon, L. B., and Claypool, G. E., 1982, Petroleum source rock richness, type and maturity for four rock units on the Alaskan North Slope -- are they sources for the two oil types?, in U.S. Geological Survey Polar Research Symposium -- abstracts with program: U.S. Geological Survey Circular 911, p. 3-31.

Magoon, L. B., and Egbert, R. M., 1986, Framework geology and sandstone composition, in Magoon, L. B., ed., Geologic studies of the Lower Cook Inlet COST No. 1.Well, Alaska Outer Continental Shelf: U.S. Geological Survey Bulletin 1596, p. 65-90.

Magoon, L. B., Griesbach, F. B., and Egbert, R. M., 1980, Nonmarine Upper Cretaceous rocks, Cook Inlet, Alaska: American Association of Petroleum Geologists Bulletin, v. 64, no. 8, p. 1259-1266.

Magoon, L. B., Hampton, M. A., Sable, E. G., Smith, R. A., and Chemlik, F. B., 1976, U.S. Geological Survey rates oil potential of S. Cook Inlet: The Oil and Gas Journal, v. 74, no. 23, p. 166-172.

Magoon, L. B., and Kirschner, C. E., 1981, Evolution of sedimentary systems during Mesozoic and Cenozoic in southern Alaska -- an overview (abs.): American Association of Petroleum Geologists Bulletin, v. 65, no. 5, p. 953.

Mancini, E. A., and Deeter, T. M., 1977, Alaska Peninsula Late Cretaceous fore-arc deposition (abs.): American Association of Petroleum Geologists Bulletin, v. 61, no. 5, p. 811.

Mancini, E. A., Deeter, T. M., and Wingate, F. H., 1978, Upper Cretaceous arc-trench gap sedimentation on the Alaska Peninsula: Geology, v. 6, no. 7, p. 437-439.

Mankinen, E. A., and Plafker, G., 1987, Paleomagnetic evidence for a Latest Pliocene and Early Pleistocene age of the upper Yakataga Formation on Middleton Island, Alaska, in Hamilton, T. D., and Galloway, J. P., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 132-136.

Marlow, M. S., 1979, Hydrocarbon prospects in Navarin basin province, northwest Bering Sea shelf: Oil and Gas Journal, v. 77, no. 44, p. 190-196.

Marlow, M. S., Carlson, P., Cooper, A. K., Karl, H., McLean, H., McMullin, R., and Lynch, M. B., 1981, Hydrocarbon resource report for proposed OCS Sale No. 83, Navarin Basin, Alaska: U.S. Geological Survey Open-File Report 81-252, 83 p.

Marlow, M. S., and Cooper, A. K., 1979, Hydrocarbon prospects for the Navarin and the Aleutian basin provinces: U.S. Geological Survey Open-File Report 79-1667, 59 p.

Marlow, M. S., and Cooper, A. K., 1980, Mesozoic and Cenozoic structural trends under southern Bering Sea shelf: American Association of Petroleum Geologists Bulletin, v. 64, no. 12, p. 2139-2155.

Marlow, M. S., and Cooper, A. K., 1984, Summary geologic report for the north Aleutian Shelf (OCS) planning area, Bering Sea, Alaska: U.S. Geological Survey Open-File Report 84-773, 29 p.

Marlow, M. S., Cooper, A. K., and Scholl, D. W., 1977, Mesozoic structural trends beneath the southern Bering Sea Shelf (abs.): Abstracts with Programs, Geological Society of America, v. 9, no. 4, p. 460-461.

Marlow, M. S., Cooper, A. K., and Scholl, D. W., 1980, Hydrocarbon prospects of Bering Sea shelf south of St. Lawrence Island, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 745.

Marlow, M. S., Gardner, J. V., Vallier, T. L., McLean, H., Scott, E. W., and Lynch, M. B., 1979, Resource report for proposed OCS Lease Sale No. 70, St. George Basin, shelf area, Alaska: U.S. Geological Survey Open-File Report 79-1650, 79 p.

Marlow, M. S., Scholl, D. W., Cooper, A. K., and Jones, D. L., 1979, Mesozoic rocks from the Bering Sea -- the Alaska-Siberia connection (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 3, p. 90.

Marshal, B. V., Cooper, A. K., and Childs, J. R., 1978, Recent heat flow measurements in the Aleutian Basin, Bering Sea (abs.): EOS, v. 59, no. 4, p. 384.

Martin, G. C., 1921, Preliminary report on petroleum in Alaska: U.S. Geological Survey Bulletin 719, 83 p.

May, S. D., 1985, Free-air gravity anomaly map of the Chukchi and Alaskan Beaufort Seas, Arctic Ocean: U.S. Geological Survey Miscellaneous Investigations Series Map I-1182-E, 1 sheet, scale 1:1,000,000.

Mayfield, C. F., 1980, Comment on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 357-359.

Mayfield, C. F., Ellersieck, I., and Tailleur, I. L., 1984, Reconnaissance geologic map of the Noatak C5, D5, C6, and D7 quadrangles, Alaska: U.S. Geological Survey Open-File Report 84-396, 27 p., 1 sheet, scale 1:63,360.

Mayfield, C. F., Tailleur, I. L., and Ellersieck, I., 1983, Stratigraphy, structure, and palinspastic synthesis of the western Brooks Range, northwestern Alaska: U.S. Geological Survey Open-File Report 83-779, 58 p., 5 sheets.

Metz, P. A., 1980, Comment on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 360.

Miller, C. H., and Bath, G. D., 1969, Gravity map of Amchitka and nearby islands, Alaska: U.S. Geological Survey Geophysical Investigations Map GP-693, 1 sheet, scale 1:250,000.

Miller, D. J., 1971, Geologic map of the Yakataga district, Gulf of Alaska Tertiary province, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-610, 6 p., 1 sheet, scale 1:125,000.

Miller, J. W., Detterman, R. L., and Case, J. E., 1982, Lower Cretaceous (Albian) rocks on the Alaska Peninsula, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 83-86.

Miller, D. J., Payne, T. G., and Gryc, G., 1959, Geology of possible petroleum provinces in Alaska: U.S. Geological Survey Bulletin 1094, 131 p.

Miller, J. J., and von Huene, R., 1987, Migrated seismic-reflection lines, eastern Aleutian Trench: U.S. Geological Survey Oil and Gas Investigations Chart OC-129, 3 sheets.

Molenaar, C. M., 1980, Cretaceous stratigraphy, Chignik area, Alaska Peninsula, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 752.

Molenaar, C. M., 1981a, Depositional history and seismic stratigraphy of Lower Cretaceous rocks, National Petroleum Reserve in Alaska and adjacent areas: U.S. Geological Survey Open-File Report 81-1084, 42 p.

Molenaar, C. M., 1981b, Depositional history of the Nanushuk Group and related strata, in Albert, N.R.D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B4-B6.

Molenaar, C. M., and Bird, K. J., 1980, Stratigraphic relations of Nanushuk Group (Middle Cretaceous) and associated strata, North Slope of Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 752-753.

Molenaar, C. M., Egbert, R. M., and Krystinik, L. F., 1982, Depositional facies and reservoir potential of the Fortress Mountain Formation, central North Slope, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 32-33.

Moll, E. J., and Patton, W. W., Jr., 1982, Preliminary report on the Late Cretaceous and early Tertiary volcanic and related plutonic rocks in western Alaska, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 73-76.

Molnia, B. F., 1979, Origin of gas pockmarks and craters (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 7, p. 481-482.

Molnia, B. F., 1981a, Distribution of gas-charged sediment and pockmarks in the northeastern Gulf of Alaska, Yakutat Bay to Cross Sound, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B125-B126.

Molnia, B. F., 1981b, Distribution of continental shelf surface sedimentary units between Yakutat and Cross Sound, northeastern Gulf of Alaska: Journal of the Alaska Geological Society, v. 1., p. 60-65.

Molnia, B. F., and Carlson, P. R., 1976, Surface sedimentary units of the northern Gulf of Alaska continental shelf, in Cobb, E. H., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1975: U.S. Geological Survey Circular 733, p. 56-57.

Molnia, B. F., and Carlson, P. R., 1978, Surface sedimentary units of northern Gulf of Alaska continental shelf: American Association of Petroleum Geologists Bulletin, v. 62, no. 4, p. 633-643.

Molnia, B. F., and Carlson, P. R., 1980, Quaternary sedimentary facies on continental shelf, northeast Gulf of Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 3, p. 446-447.

Molnia, B. F., Carlson, P. R., and Kvenvolden, K. A., 1978, Gas-charged sediment areas on the northern Gulf of Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 10, no. 7, p. 458-459.

Molnia, B. F., and Rappeport, M. L., 1982, Mosaic of pockmocked sea-floor area near the Alsek River, northeastern Gulf of Alaska, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 146-148.

Monger, J. W. H., and Berg, H. C., 1987, Lithotectonic terrane map of western Canada and southeastern Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1874-B, 12 p., 1 sheet, scale 1:2,500,000.

Moore, J. C., 1974, Geologic and structural map of part of the outer Shumagin Islands, southwestern Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-815, 1 sheet, scale 1:63,360.

Moore, J. C., 1974, Geologic and structural map of the Sanak Islands, southwestern Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-817, 1 sheet, scale 1:63,360.

Moore, J. C., Byrne, T., Plumley, P. W., Reid, M., Gibbons, H., and Coe, R. S., 1983, Paleogene evolution of the Kodiak Islands, Alaska -- consequences of ridge-trench interaction in a more southerly latitude: Tectonics, v. 2, no. 3, p. 265-293.

Moore, J. C., and Connelly, W., 1979, Tectonic history of the continental margin of southwestern Alaska -- Late Triassic to earliest Tertiary, in Sisson, A., ed., The relationship of plate tectonics to Alaskan geology and resources, proceedings of the sixth Alaska Geological Society symposium held April 4-6, 1977, at Anchorage, Alaska: Alaska Geological Society, Anchorage, Alaska, p. H1-H29.

Moore, T. E., Nilsen, T. H., Grantz, A., and Tailleur, I. L., 1984, Parautochthonous Mississippian marine and nonmarine strata, Lisburne Peninsula, Alaska, in Reed, K. M., and Bartsch-Winkler, S., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1982: U.S. Geological Survey Circular 939, p. 17-21.

Morgan, L., ed., 1980, The Aleutians: Alaska Geographic, v. 7, no. 3., 224 p., 1 plate.

Mull, C. G., 1979, Nanushuk group deposition and the Late Mesozoic structural evolution of the central and western Brooks Range and Arctic Slope, in Ahlbrandt, T. S., ed., Preliminary geologic, petrologic, and paleontologic results of the study of Nanushuk Group rocks, North Slope, Alaska: U.S. Geological Survey Circular 794, p. 5-13.

Mull, C. G., 1980a, Evolution of Brooks Range thrust belt and Arctic Slope, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 754-755.

Mull, C. G., 1980b, Comment on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 361-362.

Mull, C. G., Tailleur, I. L., Mayfield, C. F., Ellersieck, I., and Curtis, S., 1982, New upper Paleozoic and lower Mesozoic stratigraphic units, central and western Brooks Range, Alaska: American Association of Petroleum Geologists Bulletin, v. 66, no. 3, p. 348-362.

Mullen, M. W., 1987, Petrology and provenance of sandstones of the Naknek Formation, Alaska Peninsula, in Hamilton, T. D., and Galloway, J. P., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 86-90.

Murphy, J. M., and Decker, J., 1985, Goodnews terrane and Kuskokwim Group, Eek Mountains, southwest Alaska -- open marine to trench-slope transition (abs.): American Association of Petroleum Geologists Bulletin, v. 69, no. 4, p. 672.

Naidu, A. S., Burrell, D. C., Hood, D. W., and Dygas, J. A., Texture, clay mineralogy, and chemistry of bottom sediments, west Beaufort Sea, Arctic Ocean, 1975, in Forbes, R. B., ed., Contributions to the geology of the Bering Sea Basin and adjacent regions: Geological Society of America Special Paper 151, p. 49-58.

Neel, T. H., 1977, Both onshore and offshore Alaska hold vast exploration potential: The Oil and Gas Journal, v. 75, no. 26, p. 198-202.

Nelson, H., Thor, D. R., Sandstrom M. W., and Kvenvolden, K. A., 1979, Modern biogenic gas-generated craters (sea-floor "pockmarks") on the Bering Shelf, Alaska: Geological Society of America Bulletin, Part 1, v. 90, no. 12, p. 1144-1152.

Nelson, S. W., 1980, Comment on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 364-365.

Nelson, S. W., Blome, C. D., and Karl, S. M., 1987, Late Triassic and Early Cretaceous fossil ages from the McHugh Complex, southern Alaska, in Hamilton, T. D., and Galloway, J. P., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 96-98.

Nelson, W. H., 1955, Geology of Segula, Davidof, and Khvostof Islands, Alaska: U.S. Geological Survey Bulletin 1028-K, p. 257-266.

Nilsen, T. H., 1982, Accretion model for the Cretaceous Chugach terrane, southern Alaska, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 93-97.

Nilsen, T. H., 1984, Miocene back-arc tidal deposits of the Bear Lake Formation, Alaska Peninsula, in Reed, K. M., and Bartsch-Winkler, S., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1982: U.S. Geological Survey Circular 939, p. 85-88.

Nilsen, T. H., Brosge, W. P., Moore, T. E., Dutro, J. T., Jr., and Balin, D. F., 1982, Significance of the Endicott Group for tectonic models of the Brooks Range, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 28-32.

Nilsen, T. H., and Moore, G. W., 1979, Reconnaissance study of Upper Cretaceous to Miocene stratigraphic units and sedimentary facies, Kodiak and adjacent islands, Alaska: U.S. Geological Survey Professional Paper 1093, 34 p.

Nilsen, T. H., and Moore, T. E., 1982, Fluvial-facies model for the Upper Devonian and Lower Mississippian(?) Kanayut Conglomerate, Brooks Range, Alaska, in Embry, A. F., and Balkwill, H. R., eds., Arctic geology and geophysics -- proceedings of The Third International Symposium on Arctic Geology: Canadian Society of Petroleum Geologists Memoir No. 8, p. 1-12.

Nilsen, T. H., and Moore, T. E., 1984, The Kanayut Conglomerate in the easternmost Brooks Range, Alaska, in Coonrad, W. L., and Elliott, R. L., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1981: U.S. Geological Survey Circular 868, p. 12-16.

Nilsen, T. H., and Moore, T. E., 1985, Tectonic significance of Kanayut Conglomerate and related Middle Paleozoic deposits, Brooks Range, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 69, no. 4, p. 673.

Nilsen, T. H., Moore, T. E., and Dutro, J. T., Jr., 1980, Sedimentology of fluvial Upper Devonian Kanayut Conglomerate, Brooks Range, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 758.

Nilsen, T. H., and Patton, W. W., Jr., 1984, Cretaceous fluvial to deep-marine deposits of the central Yukon-Koyukuk basin, Alaska, in Reed, K. M., and Bartsch-Winkler, S., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1982: U.S. Geological Survey Circular 939, p. 37-40.

Nokleberg, W. J., and Churkin, M., Jr., 1980a, Reply on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 355.

Nokleberg, W. J., and Churkin, M., Jr., 1980b, Reply on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v. 8, no. 8, p. 360-361.

Nokleberg, W. J., and Churkin, M., Jr., 1980c, Reply on 'collision-deformed Paleozoic continental margin, western Brooks Range, Alaska': Geology, v 8, no. 8, p. 365-366.

Nur, A., and Ben-Avraham, 1983, Break-up and accretion tectonics, in Hashimoto, M., and Uyeda, S., eds., Accretion tectonics in the circum-Pacific region: Advances in Earth and Planetary Sciences, Terra Scientific Publishing Company, Tokyo, p. 3-18.

Owen, R. M., and Moore, J. R., 1978, Textural and mineralogical variations in the surficial sediments of Chagvan Bay, Alaska -- some stratigraphic implications of a subarctic bay: Marine Geology, v. 28, no. 1/2, p. 145-161.

Palmer, I. F., Bolm, J. G., Flett, T., Lyle, W. M., Morehouse, J. A., Riehle, J., and Emmel, K. S., 1979, Hydrocarbon reservoir and source rock characteristics from selected areas of western Alaska, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B86.

Panuska, B. C., Decker, J. E., and Berg, H. C., 1984, A preliminary paleomagnetic study of the Gravina-Nutzotin belt, southern and southeastern Alaska, in Coonrad, W. L., and Elliott, R. L., , eds., The United States Geological Survey in Alaska -- accomplishemnts during 1981: U.S. Geological Survey Circular 868, p. 117-120.

Panuska, B. C., and Stone, D. B., 1980, Geology of the Kiska Harbor Formation, Aleutian Islands -- evidence for a tectonic lineament (abs.): Abstracts with Programs, Geological Society of America, v. 12, no. 3, p. 146.

Patterson, S. O., Sullivan, D. A., Trunz, J. P., Jr., Andrews, J. K., Cox, W. J., Jr., and Miller, N. H., 1982, Techincal services contract, 1981, exploration program, interpretation report; Tetra Tech, Inc., Houston, Texas: Tetra Tech Report No. 8202, Contract No. 14-08-0001-20203, prepared for the Office of the National Petroleum Reserve in Alaska.

Patton, W. W., Jr., 1967, Regional geologic map of the Candle quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-492, 1 sheet, scale 1:250,000.

Patton, W. W., Jr., 1971, Petroleum possibilities of Yukon-Koyukuk province, Alaska, in Cram, I. H., ed., Future petroleum provinces of the United States -- their geology and potential: American Association of Petroleum Geologists Memoir 15, p. 100-104.

Patton, W. W., Jr., 1978, Maps and table describing areas of interest for oil and gas in central Alaska: U.S. Geological Survey Open-File Report 78-1-F, 2 p., 2 sheets.

Patton, W. W., Jr., and Csejtey, B., Jr., 1971, Preliminary geologic investigations of eastern St. Lawrence Island, Alaska: U.S. Geological Survey Open-File Report 71-224, 52 p.

Patton, W. W., Jr., and Csejtey, B., Jr., 1972, Analysis of stream-sediment and rock samples from St. Lawrence Island, Alaska, 1966-1971: U.S. Geological Survey Open-File Report 72-293, 82 p.

Patton, W. W., Jr., and Csejtey, B., Jr., 1979., Geologic map of St. Lawrence Island, Alaska: U.S. Geological Survey Open-File Report 79-945, 1 sheet, scale 1:250,000.

Patton, W. W., Jr., and Csejtey, B., Jr., 1980, Geologic map of St. Lawrence Island, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1203, 1 sheet, scale 1:250,000.

Patton, W. W., Jr., Lanphere, M. A., Miller, T. P., and Scott, R. A., 1975, Age and tectonic significance of volcanic rocks on St. Matthew Island, Bering Sea, Alaska: U.S. Geological Survey Open-File Report 75-150.

Patton, W. W., Jr., and Miller, T. P., 1968, Regional geologic map of the Selawik and southeastern Baird Mountains quadrangles, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-530, 1 sheet, scale 1:250,000.

Patton, W. W., Jr., Miller, T. P., Berg, H. C., Gryc, G., Hoare, J. M., and Ovenshine, A. T., 1975, Reconnaissance geologic map of St. Matthew Island, Bering Sea, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-642, 1 sheet, scale 1:125,000.

Patton, W. W., and Moll, E. J., 1982, Structural and stratigraphic sections along a transect between the Alaska Range and Norton Sound, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 76-78.

Patton, W. W., Jr., and Tailleur, I. L., 1977, Evidence in the Bering Sea region for differential movement between North America and Eurasia: Geological Society of America Bulletin, v. 88, no. 9, p. 1298-1304.

Pavlis, T. L., 1982, A metamorphosed, pre-Jurassic subduction complex(?) in the western Chugach Mountains, Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 14, no. 4, p. 224.

Payne, T. G., et al., 1952, Geology of the Arctic Slope of Alaska: U.S. Geological Survey Oil and Gas Investigations Map OM-126, 3 sheets.

Petering, G. W., and Smith, T. N., 1981, Stratigraphic sections, Hallo Bay to Katmai Bay, Shelikof Strait, Alaska, 1979: U.S. Geological Survey Open-File Report 81-21, 1 sheet.

Pewe, T. L., 1975, Quaternary geology of Alaska: U.S. Geological Survey Professional Paper 835, 145 p., 1 plate, scale 1:5,000,000.

Phillips, R. L., and Colgan, M. W., 1987, Vibracore stratigraphy of the northeastern Chukchi Sea, in Hamilton, T. D., and Galloway, J. P., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 157-160.

Plafker, G., 1967, Geologic map of the Gulf of Alaska Tertiary province, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-484, 1 sheet, scale 1:500,000.

Plafker, G., 1971, Possible future petroleum resources of Pacific-margin Tertiary basin, Alaska, in Cram, I. H., ed., Future petroleum provinces of the United States -- their geology and potential: American Association of Petroleum Geologists Memoir 15, p. 120-135.

Plafker, G., Bruns, T. R., Carlson, P. R., Molnia, B. F., Scott, E. W., Kahler, R., and Wilson, C., 1978, Petroleum potential, geologic hazards, and technology for exploration in the Outer Continental Shelf of the Gulf of Alaska Tertiary province: U.S. Geological Survey Open-File Report 78-490, 33 p., 13 figures.

Plafker, G., Bruns, T. R., and Page, R. A., 1975, Interim report on petroleum resource potential and geologic hazards in the Outer Continental Shelf of the Gulf of Alaska Tertiary province: U.S. Geological Survey Open-File Report 75-592, p. 72.

Plafker, G., Carlson, P. R., Coonrad, W. L., Hunt, S. J., and Quinterno, P., 1979, Geologic implications of 1978 outcrop sample data from the continental slope in the eastern Gulf of Alaska, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B143-B146.

Plafker, G., and Claypool, G. E., 1979, Petroleum source potential of rocks dredged from the continental slope in the eastern Gulf of Alaska: U.S. Geological Survey Open-File Report 79-295, 24 p.

Plafker, G., Hudson, T., and Silberling, N. J., 1979, Late Triassic fossils from a sequence of volcanic and sedimentary rocks of the Chilkat Peninsula, southeastern Alaska, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B107-B110.

Plafker, G., Keller, G., Nelson, S. W., Dumoulin, J. A., Miller, M. L., 1985, Summary of data on the age of the Orca Group, Alaska, in Bartsch-Winkler, S., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1984: U.S. Geological Survey Circular 967, p. 74-76.

Plafker, G., Jones, D. L., and Pessagno, E. A., Jr., 1977, An Upper Mesozoic accretionary flysch and melange terrain along the Gulf of Alaska margin (abs.): Abstracts with Programs, Geological Society of America, v. 9, no. 7, p. 1131-1132.

Plafker, G., Winkler, G. R., Carlson, P. R., Bruns, T. R., and Claypool, G. E., 1979, Petroleum potential of eastern Gulf of Alaska shelf based on dredge samples from adjacent continental slope (abs.): American Association of Petroleum Geologists Bulletin, v. 63, no. 4, p. 700.

Plafker, G., Winkler, G. R., Coonrad, W. L., and Claypool, G. E., 1980, Preliminary report on the geology of the continental slope adjacent to OCS Lease Sale 55, eastern Gulf of Alaska -- petroleum resource implications: U.S. Geological Survey Open-File Report 80-1089, 72 p.

Plafker, G., Winkler, G., and Claypool, G. E., 1980, Geology of continental slope adjacent to OCS Lease Sale 55, near Yakutat, eastern Gulf of Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 766.

Plafker, G., Winkler, G. R., Coonrad, W. L., and Claypool, G. E., 1980, Geology of continental slope adjacent to Alaska lease Sale 55: Oil and Gas Journal, v. 78, no. 40, p. 112-120.

Plafker G., Winkler, G. R., Hunt, S. J., Bartsch-Winkler, S., Coonrad, W. L., and Quinterno, P., 1977, Outcrop samples from the Continental Slope in the eastern Gulf of Alaska, in Johnson, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1977: U.S. Geological Survey Circular 772-B, p. B97-B101.

Plumley, P. W., Coe, R. S., and Byrne, T., 1983, Paleomagnetism of the Paleocene Ghost Rocks Formation, Prince William terrane, Alaska: Tectonics, v. 2, no. 3, p. 295-314.

Powers, H. A., Coats, R. R., and Nelson, W. H., 1955, Geology and submarine physiography of Amchitka Island, Alaska: U.S. Geological Survey Bulletin 1028-P, p. 521-554.

Pratt, R. M., 1981, Gas hydrate evaluation and recommendations, National Petroleum Reserve - Alaska, in Bowsher, A. L., ed., Proceedings of a workshop on clathrates (gas hydrates) in the National Petroleum Reserve in Alaska, July 16-17, 1979, Menlo Park, California: U.S. Geological Survey Open-File Report 81-1298, p. 114-143.

Quinterno, P. J., 1981, Preliminary report on benthic foraminifers from Navarin Basin province, Bering Sea, Alaska, in Carlson, P. R., and Karl, H. A., eds., Seafloor geologic hazards, sedimentology, and bathymetry -- Navarin Basin province, northwestern Bering Sea: U.S. Geological Survey Open-File Report 81-1217, p. 114-129.

Quinterno, P. J., Carlson, P. R., and Molnia, B. F., 1981, Benthic foraminifers as indicators of the Pleistocene-Holocene boundary in the eastern Gulf of Alaska, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B128-130.

Rabinowitz, P. D., and Cooper, A., 1977, Structure and sediment distribution in the western Bering Sea: Marine Geology, v. 24, no. 4, p. 309-320.

Rau, W. W., Plafker, G., and Winkler, G. R., 1983, Foraminiferal biostratigraphy and correlations in the Gulf of Alaska Tertiary province: U.S. Geological Survey Oil and Gas Investigations Chart OC-120, 11 p., 3 sheets.

Redden, G. D., Rapp, J. B., and Kvenvolden, K. A., 1979, Gases in sediments of Norton Sound, Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 3, p. 123-124.

Redden, G. D., Weliky, K., Kvenvolden, K. A., and Hampton, M. A., 1980, Geochemistry of low molecular weight hydrocarbons in sediment of the western Gulf of Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 12, no. 3, p. 148.

Reid, M., and Gill, J. B., 1980, Near trench volcanism, Kodiak Island, Alaska -- implications for ridge-trench encounter (abs.): Abstracts with Programs, Geological Society of America, v. 12, no. 3, p. 148-149.

Richard, L. H., and Ressmeyer, P. F., 1985, Mississippian conodonts, Lisburne Group, St. Lawrence Island, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 69, no. 4, p. 668.

Roberts, R. W., 1985, Scenarios for petroleum development of the Norton Basin Planning Area -- northeastern Bering Sea: U.S. Minerals Management Service OCS Report MMS 85-0013, 29 p.

Roehler, H. W., and Sticker, G. D., 1979, Stratigraphy and sedimentation of the Torok, Kukpowruk, and Corwin Formations of Cretaceous age in the Kokolik-Utukok River region, National Petroleum Reserve in Alaska: U.S. Geological Survey Open-File Report 79-995, 80 p., 2 plates.

Sainsbury, C. L., 1972, Geologic map of the Teller quadrangle, western Seward Peninsula, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-685, 4 p., 1 sheet, scale 1:250,000.

Sallenger, A. H., Jr., and Hunter, R. E., 1984, Maps showing the coastal morphology of the Bristol Bay coast of the Alaska Peninsula: U.S. Geological Survey Miscellaneous Field Studies Map MF-1672, 2 sheets, scale 1:400,000.

Samuels, W. B., Banks, D., and Hopkins, D., 1983, An oilspill risk analysis for the Diapir Field (June 1984) Outer Continental Shelf lease offering: U.S. Geological Survey Open-File Report 83-570, 138 p.

Samuels, W. B., and Hopkins, D., 1981, An oilspill risk analysis for the St. George Basin, Alaska, (Proposed Sale 70) Outer Continental Shelf lease area: U.S. Geological Survey Open-File Report 81-864, 89 p.

Sandstrom, M., Reed, W. E., and Kaplan, I. R., 1977, Recycling of organic matter in recent sediments from the southeastern Bering Sea and western Gulf of Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 9, no. 4, p. 1154.

Savage, N. M., Eberlein, G. D., and Churkin, M., Jr., 1977, Early Devonian conodonts from the Karheen Formation, eastern Heceta Island, southeastern Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 9, no. 4, p. 496.

Scholl, D. W., Alpha T. R., Marlow, M. S., and Buffington, E. C., 1974, Base map of the Aleutian-Bering Sea region: U.S. Geological Survey Miscellaneous Investigations Series Map I-879, 1 sheet, scale 1:2,500,000.

Scholl, D. W., Buffington, E. C., and Marlow, M. S., 1975, Plate tectonics and the structural evolution of the Aleutian-Bering Sea region, in Forbes, R. B., ed., Contributions to the geology of the Bering Sea Basin and adjacent regions: Geological Society of America Special Paper 151, p. 1-31.

Scholl, D. W., and Cooper, A. K., 1978, VAMPs -- possible hydrocarbon bearing structures in Bering Sea basin: American Association of Petroleum Geologists Bulletin, v. 62, no. 12, p. 2481-2488.

Scholl, D. W., Marlow, M. S., and Buffington, E. C., 1976, Cenozoic and Mesozoic petroleum prospects, Aleutian-Bering Sea region -- summary (abs.), in Halbouty, M. T., Maher, J. C., and Lian, H. M., eds., Circum-Pacific energy and mineral resources: American Association of Petroleum Geologists Memoir 25, p. 280.

Scholl, D. W., and Vallier, T., 1979, Crustal tectonics at the intersection of the Aleutian Trench and the Amlia Fracture Zone (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 3, p. 126.

Scholl, D. W., Vallier, T. L., and Stevenson, A. J., 1983, Arc, forearc, and trench sedimentation and tectonics; Amlia corridor of the Aleutian Ridge in Watkins, J. S., and Drake, C. L., eds., Studies in continental margin geology: American Association of Petroleum Geologists Memoir No. 34, p. 413-439.

Schwab, W. C., and Bruns, T. R., 1979, Preliminary residual magnetic map of the northern Gulf of Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1054, 1 sheet, scale 1:500,000.

Schwab, W. C., Bruns, T. R., and von Huene, R., 1980, Maps showing structural interpretation of magnetic lineaments in the northern Gulf of Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1245, 1 sheet, scale 1:1,500,000.

Sears, J. W., and Price, R. A., 1978, The Siberian connection -- a case for Precambrian separation of the North American and Siberian cratons: Geology, v. 6, no. 5, p. 267-270.

Sears, J. W., and Price, R. A., 1979, Reply on 'the Siberian connection -- a case for Precambrian separation of the North American and Siberian cratons': Geology, v. 7, no. 11, p. 467.

Seeber, L., and Armbruster, J., 1979, The Himalayan and the Alaska-Aleutian convergence zones -- a similar pattern of active crustal tectonics and seismisicity (abs.): EOS, v. 60, no. 18, p. 390.

Seely, D. R., and Dickinson, W. R., 1977, Stratigraphy and structure of compressional margins, in Curray, J. R., Dickinson, W. R., Dow, W. G., Emery, K. O., Seely, D. R., Vail, P. R., and Yarborough, H., Geology of continental margins: American Association of Petroleum Geologists Education Course Note Series No. 5, p. C1-C23.

Sharma, G. D., 1975, Contemporary epicontental sedimentation and shelf grading in the southeast Bering Sea, in Forbes, R. B., ed., Contributions to the geology of the Bering Sea Basin and adjacent regions: Geological Society of America Special Paper 151, p. 33-48.

Silberling, N. J., Wardlaw, B. R., and Berg, H. C., 1982, New paleontologic age determinations from the Taku terrane, Ketchikan area, southeastern Alaska, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 117-119.

Simons, F. S., and Mathewson, D. E., 1955, Geology of Great Sitkin Island, Alaska: U.S. Geological Survey Bulletin 1028-B, p. 21-43.

Simpson, G. L., Vallier, T. L., Pearl, J. E., and Lee-Wong, F., 1979, Potassium-argon ages and geochemistry of basalt dredged near Saint George Island, southern Bering Sea, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B134-B135.

Smith, J. G., Elliott, R. L., Berg, H. C., and Wiggins, B. D., 1977, Map showing general geology and location of chemically and radiometrically analyzed samples in parts of the Ketchikan, Bradfield Canal, and Prince Rupert quadrangles, southeastern Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-825, 2 sheets, scale 1:250,000.

Smith, T. N., and Petering, G. W., 1981, Petroleum potential of Shelikof Strait based on outcrops in Katmai National Monument, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 65, no. 5, p. 994.

Snyder, G. L., 1955, Ocean floor structures, northeastern Rat Islands, Alaska: U.S. Geological Survey Bulletin 1028-G, p. 161-167.

Snyder, G. L., 1955, Geology of Little Sitkin Island, Alaska: U.S. Geological Survey Bulletin 1028-H, p. 169-210.

Sonnevil, R. A., 1981, The Chilkat-Prince of Wales plutonic province, southeastern Alaska, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B112-B115.

Steele, W. C., 1978, Interpretation of landsat imagery of the Goodnews and Hagemeister Island quadrangles region, southwestern Alaska: U.S. Geological Survey Open-File Report 78-9-D, 1 sheet, scale 1:250,000.

Stewart, R. J., 1978, Neogene volcaniclastic sediments from Atka basin, Aleutian Ridge: American Association of Petroleum Geologists Bulletin, v. 62, no. 1, p. 87-97.

Stone, D. B., 1975, Paleomagnetic studies and tectonics in the Aleutian Islands, in Forbes, R. B., ed., Contributions to the geology of the Bering Sea Basin and adjacent regions: Geological Society of America Special Paper 151, p. 59-75.

Stone, D. B., 1979, Paleomagnetism and paleographic reconstruction of southern Alaska, in Sisson, A., ed., The relationship of plate tectonics to Alaskan geology and resources, proceedings of the sixth Alaska Geological Society symposium held April 4-6, 1977, at Anchorage, Alaska: Alaska Geological Society, Anchorage, Alaska, p. K1-K17.

Stone, D. B., and Packer, D. R., 1978, Paleomagnetic data from the Alaska Peninsula: Geological Society of America Bulletin, Part 1, v. 90, no. 6, p. 454-560.

Tailleur, I. L., and Bowsher, A. L., 1981a, Abstract for clathrate meeting hydrates in Tunalik No. 1, ONPRA (abs.), in Bowsher, A. L., ed., Proceedings of a workshop on clathrates (gas hydrates) in the National Petroleum Reserve in Alaska, July 16-17, 1979, Menlo Park, California: U.S. Geological Survey Open-File Report 81-1298, p. 147.

Tailleur, I. L., and Bowsher, A. L., 1981b, Potential fuel resource of coal-gas clathrate in northwestern Alaska, in Bowsher, A. L., ed., Proceedings of a workshop on clathrates (gas hydrates) in the National Petroleum Reserve in Alaska, July 16-17, 1979, Menlo Park, California: U.S. Geological Survey Open-File Report 81-1298, p. 148-150.

Tailleur, I. L., and Brosge, W. P., 1970, Tectonic history of northern Alaska, in Adkison, W. L., and Brosge, M. M., eds., Geological seminar on the North Slope of Alaska: Pacific Section, American Association of Petroleum Geologists, Los Angeles, California, p. E1-E19.

Teseneer, R., Gibson, C., Seidlitz, A., and Borkoski, J., 1987, Oil and gas assessment of the Kenai National Wildlife Refuge: U.S. Department of the Interior, Bureau of Land Management, unpublished report prepared for the U.S. Fish and Wildlife Service, 91 p., 3 sheets.

Teseneer, R., Foland, R., Seidlitz, A., and Borkoski, J., 1988, Oil and gas assessment of the Selawik National Wildlife Refuge: U.S. Department of the Interior, Bureau of Land Management, unpublished report prepared for the U.S. Fish and Wildlife Service, 75 p., 3 sheets.

Thompson, T. L., 1976, Plate tectonics in petroleum exploration of convergent continental margins, in Halbouty, M. T., Maher, J. C., and Lian, H. M., eds., Circum-Pacific energy and mineral resources: American Association of Petroleum Geologists Memoir 25, p. 177-188.

Thor, D. R., and Nelson, C. H., 1981, Environmental geologic studies of the northern bering Sea, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B121-B122.

Thor, D. R., and Nelson, H., 1977, Environmental geologic studies in northern Bering Sea, in Johnson, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1977: U.S. Geological Survey Circular 772-B, p. B94-B95.

Thrupp, G. A., and Coe, R. S., 1986, Early Tertiary paleomagnetic evidence and the displacement of southern Alaska: Geology, v. 14, no. 3, p. 213-217.

Thurston, S. P., 1985, Structure, petrology, and metamorphic history of the Nome Group blueschist terrane, Salmon Lake area, Seward Peninsula, Alaska: Geological Society of America Bulletin, v. 96, no. 5, p. 600-617.

Till, A. B., Dumoulin, J. A, Gambel, B. M., Kaufman, D. S., and Carroll, P.I., 1986, Preliminary geologic map and fossil data, Solomon, Bendeleben, and southern Kotzebue quadrangles, Seward Peninsula, Alaska: U.S. Geological Survey Open-File Report 86-276, 60 p., 3 sheets, scale 1:250,000.

Turner, D. L., and Swanson, S. E., 1981, Continental rifting -- a new tectonic model for the central Seward Peninsula, in Wescott, E., and Turner, D. L., eds., Geothermal reconnaissance survey of the central Seward Peninsula, Alaska: University of Alaska, Geophysical Institute Report UAG R-284, p. 7-36.

Turner, R. F., ed., Bolm, J. G., McCarthy, C. M., Steffy, D. A., Lowry, P., Flett, T. O., and Blunt, D., 1983a, Geological and operational summary Norton Sound COST No. 1 well, Norton Sound, Alaska: U.S. Geological Survey Open-File Report 83-124, 170 p.

Turner, R. F., ed., Bolm, J. G., McCarthy, C. M., Steffy, D. A., Lowry, P., Flett, T. O., and Blunt, D., 1983b, Geological and operational summary Norton Sound COST No. 2 well, Norton Sound, Alaska: U.S. Geological Survey Open-File Report 83-557, 161 p.

Turner, R. F., ed., Martin, G. C., Risley, D. E., Steffy, D. A., Flett, T. O., and Lynch, M. B., 1986, Geologic report for the Norton Basin Planning Area, Bering Sea, Alaska: U.S. Department of the Interior, Minerals Management Service OCS Report MMS 86-0033, 179 p.

Tussing, A. R., and Barlow, C. C., 1984, The natural gas industry, evolution, structure, and economics: Ballinger Publishing Company, Cambridge, Massachusetts.

Tysdal, R. G., and Case, J. E., 1977, The McHugh Complex in the Seward quadrangle, south-central Alaska, in Blean, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1976: U.S. Geological Survey Circular 751-B, p. B48-B49.

Tysdal, R. G., and Case, J. E., 1979, Geologic map of the Seward and Blying Sound quadrangles, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-1150, 12 p., 1 sheet, scale 1:250,000.

Vallier, T. L., and Herman, B. M., 1987, Petrology, age, and original tectonic setting of basalt from the St. George Basin COST No. 1 well, southern Bering Sea, in Hamilton, T. D., and Galloway, J. P., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1986: U.S. Geological Survey Circular 998, p. 165-169.

Vallier, T. L., Underwood, M. B., Gardner, J. V., and Barron, J. A., 1980, Neogene sedimentation on the outer continental margin, southern Bering Sea: Marine Geology, v. 36, no. 3/4, p. 269-287.

Vallier, T. L., Underwood, M. B., Jones, D. L., and Gardner, J. V., 1980, Petrography and geologic significance of Upper Jurassic rocks dredged near Pribilof Islands, southern Bering Sea continental shelf: American Association of Petroleum Geologists Bulletin, v. 64, no. 6, p. 945-950.

Venkatesan, M. I., Kaplan, I. R., and Ruth, E., 1983, Hydrocarbon geochemistry in surface sediments of Alaskan Outer Continental Shelf -- Part 1. C15+ hydrocarbons: American Association of Petroleum Geologists Bulletin, v. 67, no. 5, p. 831-840.

Vogel, T. M., and Kvenvolden, K. A., 1981, Hydrocarbon gases in Navarin Basin province sediments, in Carlson, P. R., and Karl, H. A., eds., Seafloor geologic hazards, sedimentology, and bathymetry -- Navarin Basin province, northwestern Bering Sea: U.S. Geological Survey Open-File Report 81-1217, p. 80-99.

von Huene, R., 1977a, A structural interpretation of the eastern Aleutian Trench and adjacent continental margin off Kodiak Island, Alaska (abs.), in Curray, J. R., Dickinson, W. R., Dow, W. G., Emery, K. O., Seely, D. R., Vail, P. R., and Yarborough, H., Geology of continental margins: American Association of Petroleum Geologists Education Course Note Series No. 5, p. G6-G7.

von Huene, R., 1977b, Structural interpretation of eastern Aleutian Trench and adjacent continental margin off Kodiak Island, Alaska (abs.): American Association of Petroleum Geologists Bulletin, v. 61, no. 5, p. 838-839.

von Huene, R., 1979, Structure of the outer convergent margin of Kodiak Island, Alaska, from multichannel seismic records, in Watkins, J. S., Montadert, L., and Dickerson, P. W., eds., Geological and geophysical investigations of continental margins: American Association of Petroleum Geologists Memoir 29, p. 261-272.

von Huene, R., Bouma, A., Moore, G., Hampton, M., Smith, R., and Dolton, G., 1976, A summary of petroleum potential, environmental geology, and the technology, timeframe, and infrastructure for exploration and development of the western Gulf of Alaska: U.S. Geological Survey Open-File Report 76-325, 92 p.

von Huene, R., Box, S. E., Detterman, R. L.,, Fisher, M. A., Moore, J. C., and Pulpan, H., 1985, Transect A2 -- Kodiak to Kuskokwim, Alaska: Geological Society of America, North American Continent-Ocean Transects Program, Transect No. 6, 14 p., 1 sheet.

von Huene, R., Bruns, T., and Fisher, M., 1981, Subduction-related structure along eastern Aleutian Trench (abs.): American Association of Petroleum Geologists Bulletin, v. 65, no. 5, p. 1004.

von Huene, R., Fisher, M. A., and Bruns, T. R., 1979, Continental margins of the Gulf of Alaska and Late Cenozoic tectonic plate boundaries, in Sisson, A., ed., The relationship of plate tectonics to Alaskan geology and resources, proceedings of the sixth Alaska Geological Society symposium held April 4-6, 1977, at Anchorage, Alaska: Alaska Geological Society, Anchorage, Alaska, p. J1-J33.

von Huene, R., Fisher, M. A., Hampton, M. A., and Lynch, M., 1980, Petroleum potential, environmental geology, and the technology for exploration and development of the Kodiak lease sale area #61: U.S. Geological Survey Open-File Report 80-1082, 70 p.

von Huene, R., Hampton, M. A., Fisher, M. A., Varchol, D. J., and Cochrane, G. R., 1980, Map showing near-surface geologic structures of Kodiak Shelf, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1200, 1 sheet, scale 1:500,000.

von Huene, R., Lathram, E. H., and Reimnitz, E., 1971, Possible petroleum resources offshore Pacific-margin Tertiary basin, Alaska, in Cram, I. H., ed., Future petroleum provinces of the United States -- their geology and potential: American Association of Petroleum Geologists Memoir 15, p. 136-151.

von Huene, R., Moore, G. W., Moore, J. C., and Stephens, C. D., 1979, Cross section, Alaska Peninsula-Kodiak Island-Aleutian Trench -- summary: Geological Society of America Bulletin, Part 1, v. 90, no. 5, p. 427-430.

von Huene, R., Shor, G. G., Jr., and Wageman J., 1979, Continental margins of the eastern Gulf of Alaska and boundaries of tectonic plates, in Watkins, J. S., Montadert, L., and Dickerson, P. W., eds., Geological and geophysical investigations of continental margins: American Association of Petroleum Geologists Memoir 29, p. 273-290.

Wahrhaftig, C., 1965, Physiographic divisions of Alaska: U.S. Geological Survey Professional Paper 482, 52 p., 6 plates.

Waldron, H. H., 1955, Geologic reconnaissance of Frosty Peak Volcano and vicinity, Alaska: U.S. Geological Survey Bulletin 1028-T, p. 677-708.

Webster, J. H., 1984, Preliminary report on a large granitic body in the Coast Mountains, northeast Petersburg Quadrangle, southeastern Alaska, in Reed, K. M., and Bartsch-Winkler, S., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1982: U.S. Geological Survey Circular 939, p. 116-118.

Whitney, J., Hoose, P. J., Smith, L. M., and Lybeck, L., 1980, Geologic cross sections of the Outer Continental Shelf of Shelikof Strait, Alaska: U.S. Geological Survey Open-File Report 80-2036, 1 sheet.

Williams, J. R., 1979, Stratigraphy of the Gubik Formation at Skull Cliff, northern Alaska, in Johnson, K. M., and Williams, J. R., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1978: U.S. Geological Survey Circular 804-B, p. B31-B33.

Williams, J. R., 1983, Engineering-geologic maps of northern Alaska, Wainwright quadrangle: U.S. Geological Survey Open-File Report 83-457, 28 p., 1 sheet, scale 1:250,000.

Williams, J. R., Carter, L. D., and Yeend, W. E., 1977, Coastal plain deposits of NPRA, in Johnson, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1977: U.S. Geological Survey Circular 772-B, p. B20-B22.

Wills, J. C., Bolm, J. G., Stewart, G. H., Turner, R. F., Lynch, M. B., Petering, G. W., Parker, J., and Schoof, B., 1978, Geological and operational summary, Atlantic Richfield Lower Cook Inlet, Alaska, Cost Well No. 1: U.S. Geological Survey Open-File Report 78-145, 46 p.

Wilson, F. H., 1981, K-Ar ages on intrusive rocks and altered zones in the Chignik and and Sutwik Island quadrangles, in Albert, N. R. D., and Hudson, T., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1979: U.S. Geological Survey Circular 823-B, p. B45-B46.

Wilson, F. H., Case, J. E., and Detterman, R. L., 1985, Preliminary description of a Miocene zone of structural complexity, Port Moller and Stepovak Bay quadrangles, in Bartsch-Winkler, S., and Reed, K. M., eds., The United States Geological Survey in Alaska -- accomplishemnts during 1983: U.S. Geological Survey Circular 945, p. 54-56.

Wilson, F. H., Detterman, R. L., and Silberman, M. L., 1977, New ages on intrusive rocks and altered zones on the Alaska Peninsula, in Johnson, K. M., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1977: U.S. Geological Survey Circular 772-B, p. B63-B65.

Wilson, F. H., Gaum, W. C., and Herzon, P. L., 1981, Geochronology and geochemistry, Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1053-M, 3 sheets, scale 1:250,000.

Wilson, F. H., and Shew, N., 1982, Preliminary results of potassium-argon age determinations from the Ugashik quadrangle, Alaska Peninsula, in Coonrad, W. L., ed., The United States Geological Survey in Alaska -- accomplishemnts during 1980: U.S. Geological Survey Circular 844, p. 86-87.

Winkler, G. R., 1976, Deep-sea fan deposition of the Lower Tertiary Orca Group, eastern Prince William Sound, Alaska: U.S. Geological Survey Open-File Report 76-83, 20 p.

Winkler, G. R., and Miller, R. J., 1979, Disparate terranes proximal to the Border Ranges fault system in the Valdez quadrangle, southern Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 11, no. 7, p. 542.

Winkler, B. R., Miller, R. J., and Case, J. E., 1980, Blocks and belts of blueschist and greenschist in the Valdez quadrangle, Chugach Mountains, southern Alaska (abs.): Abstracts with Programs, Geological Society of America, v. 12, no. 3, p. 160.

Wolfe, J. A., Hopkins, D. M., and Leopold, E. B., 1966, Tertiary stratigraphy and paleobotany of the Cook Inlet region, Alaska: U.S. Geological Survey Professional Paper 398-A, 29 p., 2 sheets, scale 1:1,000,000.

Wolf, J. A., and Tanai, T., 1980, The Miocene Seldovia Point flora from the Kenai Group, Alaska: U.S. Geological Survey Professional Paper 1105, 52 p., 25 plates.

APPENDIX A

MEMORANDUM OF UNDERSTANDING
BETWEEN THE
FISH AND WILDLIFE SERVICE
AND THE
BUREAU OF LAND MANAGEMENT
U.S. DEPARTMENT OF THE INTERIOR

BACKGROUND:

Section 1008 of the Alaska National Interest Lands Conservation Act (ANILCA) requires the Secretary of the Interior to initiate an oil and gas leasing program on the federal lands of Alaska; it exempts, ". . . those units of the National Wildlife Refuge System where the Secretary determines, after having considered the national interest in producing oil and gas would be incompatible with the purpose for which such unit was established." Section 1008 also mandates that:

> "In such areas as the Secretary deems favorable for the discovery of oil or gas, he shall conduct a study, or studies, or collect and analyze information obtained by permittees authorized to conduct studies under this section, of the oil and gas potential of such lands and those environmental characteristics and wildlife resources which would be affected by the exploration for and development of such oil and gas."

Section 304(g) of ANILCA requires that the Secretary of the Interior prepare a "comprehensive conservation plan" for each of the 16 National Wildlife Refuges in the State of Alaska. Among other things, these plans are to, ". . . specify the uses within each such area which may be compatible with the major purposes of the refuge." The U.S. Fish and Wildlife Service (FWS) has the responsibility for preparing the refuge comprehensive conservation plans and is using the refuge planning process to define those areas on refuges where oil and gas exploration and development may be compatible with the purposes for which each refuge was established.

PURPOSE:

To fully comply with Section 1008 of ANILCA (i.e., to consider the national interest in producing oil and gas from refuge lands) an accurate defensible oil and gas resource assessment should be prepared for each National Wildlife Refuge in Alaska. The FWS has limited technical expertise in assessing mineral potentials. However, this expertise does exist within the U.S. Bureau of Land Management (BLM). The purpose of this memorandum is to establish cooperative procedures between the FWS and the BLM for the mutual responsibility of assessing the oil and gas potential of National Wildlife Refuge lands in Alaska.

IT IS MUTUALLY AGREED THAT:

The BLM will develop an oil and gas resource assessment for each of the 16 National Wildlife Refuges in the State of Alaska. These assessments will consist of the following items (to the extent that available data permits):

1. A detailed narrative discussion of the geologic character of the refuge.

2. A map showing all known geologic formations and geologic features pertinent to the mineral assessment.

3. A geologic cross section showing the subsurface character of the study area.

4. A detailed discussion of the engineering aspects, if there is a potential for development in the area, including the types of facilities and the infrastructure necessary to economically develop the hydrocarbon potential.

5. A generic development scenario map that will graphically portray the facilities and infrastructure discussed in item 4 above.

6. An economic assessment that will include:

    a. a brief overview of the national energy situation and discussion of the importance of Alaskan oil and gas production.

    b. a generalized discussion of the economic potential for oil and gas production from the refuge being evaluated.

    c. a discussion of the factors that may affect future oil and gas development on the refuge.

The above six items shall be considered the minimum elements to be included in any refuge assessment. If sufficient nonproprietary geological and geophysical data exist, and the hydrocarbon resources warrant further description, some or all of the following items (time permitting) will also be included in the resource assessment:

a. structural contour maps showing the location and surface areas of potential mineral occurrences,

b. maps showing the magnetic and/or gravity character of the area,

c. maps showing the thickness of identified rock formations,

d. reservoir character map showing the porosity, water saturation, and permeability characteristics of potential reservoirs, and

e. a detailed development scenario map showing roads, docks, pipeline corridors, etc. required to develop the prospects.

In preparing the oil and gas resource assessments, the BLM shall make use of (1) existing literature, (2) geological and geophysical information and data collected from FWS lands by industry permittees (see Memorandum of Understanding between FWS and BLM dated August 1984--attachment 1), and (3) geological and geophysical information and data collected on or adjacent to FWS lands by the BLM, the U.S. Geological Survey, the State of Alaska, and other government agencies. During the evaluation process, BLM geologists will make official contacts with mineral companies that may have an interest in the area. These companies will be given an opportunity to submit data for consideration and they will also be given the opportunity to discuss their feelings on the study area and its oil and gas development potential with the evaluating geologists. All interactions will be documented ans submitted to the Fish and Wildlife Service at the close of the project.

The oil and gas resource assessments prepared by BLM will be delivered to the FWS in form suitable for public release. These assessments will be public documents, and the FWS will make copies of the assessments available for public review. All formal communications with the public concerning the management of FWS lands (e.g., the opening of refuge lands to oil and gas exploration or development) will be the responsiblilty of the FWS.

In developing the oil and gas assessment, proprietary information that was obtained by the BLM will be shared with the FWS as support for statements made in the assessment; however, proprietary information will not be included in the public report.

The number of refuge resource assessments that BLM will complete each year and the amount of funding that FWS will provide to BLM will be determined on an annual basis by mutual agreement. The following three goals have been established to assist the FWS and the BLM in planning their work commitment for completing the refuge oil and gas assessments:

1. The Becharof, Alaska Peninsula, Yukon Flats and Kenai National Wildlife Refuge oil and gas assessments will be completed during the 1986 fiscal year.

2. If at all possible, the oil and gas assessments for the remaining 12 refuges will be completed during the 1987 and 1988 fiscal years.

3. The FWS will reimburse the BLM for completion of oil and gas assessments and FWS will prioritize the assessments to be completed each year, with consideration for concurrently conduction analyses, if possible, on refuges in similar geographic location or of similar geologic character.

However, nothing in this MOU shall be construed as requiring either agency to assume or expend any funds in excess of appropriations available. The remaining 12 National Wildlife Refuge (NWR) resource assessments will be conducted in the priority order established by the FWS on an annual basis:

1. Togiak NWR
2. Tetlin NWR
3. Kanuti NWR
4. Yukon Delta NWR
5. Koyukuk NWR
6. Nowitna NWR
7. Innoko NWR
8. Selawik NWR
9. Kodiak NWR
10. Alaska Maritime NWR
11. Izembek NWR
12. Artic NWR

Amendments to this agreement may be proposed by either party and shall become effective upon mutual approval. Meetings to discuss the MOU may be called by the FWS Regional Director or the BLM State Director.

/s/ Robert E. Gilmore	3/17/86
Regional Director U.S. Fish and Wildlife Service	Date
s/ Michael J. Penfold	2/26/86
State Director Bureau of Land Management	Date

Attachment 1

MEMORANDUM OF UNDERSTANDING
BETWEEN THE
FISH AND WILDLIFE SERVICE
AND THE
BUREAU OF LAND MANAGEMENT
U.S. DEPARTMENT OF THE INTERIOR

ARTICLE 1 Background and objectives

Jointly, the Fish and Wildlife Service (FWS) and the Bureau of Land Management (BLM) share responsibility to help meet Department of the Interior objectives in Section 1008 of the Alaska National Interest Lands Conservation Act (ANILCA), of December 1980. The FWS is authorized to issue permits for the study of oil and gas on national wildlife refuges; the BLM may analyze resulting data for identification of potential.

The FWS is issuing permits for surface geology on all refuges. Permits for geophysical exploration may be issued on refuges having approved Comprehensive Conservation Plans. Data from both activities are required to be furnished to the FWS.

This Memorandum of Understanding is entered into to initiate the role of BLM to accept such data from FWS and be responsible for its confidentiality.

ARTICLE 2 Statement of work

The FWS agrees to deliver to BLM data collected from permittees of oil and gas studies provided for in Section 1008 of ANILCA. The BLM agrees to accept the data, store it, and keep it confidental.

ARTICLE 3 Term and modification

This understanding shall continue from date of signature ten years hence. It may by modified and/or extended by mutual agreement, and terminated by either party with sixty day's notice.

/s/ Robert E. Putz — 8/8/84
Regional Director — Date
Fish and Wildlife Service

/s/ Michael J. Penfold — 8/27/84
State Director — Date
Bureau of Land Management

APPENDIX B

BLM's Mineral Potential Classification System
(from BLM Manual, Chapter 3131)

Mineral Potential Classification System

I. Level of Potential

O. The geologic environment, the inferred geologic processes, and the lack of mineral occurrences do not indicate potential for accumulation of mineral resources.

L. The geologic environment and the inferred geologic processes indicate low potential for accumualtion of mineral resources.

M. The geologic environment, the inferred geologic processes, and the reported mineral occurrences or valid geochemical/geophysical anomaly indicate moderate potential for accumulation of mineral resources.

H. The geologic environment, the inferred geologic processes, the reported mineral occurrences and/or valid geochemical/geophysical anomaly, and the known mines or deposits indicate high potential for accumulation of mineral resources. The "known mines or deposits" do not have to be within the area that is being classified, but have to be within the same type of geologic environment.

ND. Mineral(s) potential not determined due to lack of useful data. This notation does not require a level-of-certainty qualifier.

II. Level of Certainty

A. The available data are insufficient and/or cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral resources within a respective area.

B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.

C. The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.

D. The available data provide abundant direct and indirect evidenceto support or refute the possible existence of mineral resources.

For the determination of No Potential, use O/D. This class shall be seldom used, and when used it should be for a specific commodity only. For example, if the available data show that the surface and subsurface types of rock in the respective area is batholithic (igneous intrusive), one can onclude, with reasonable certainty, that the area does not have potential for coal.

As used in this classification, potential refers to potential for the presence (occurrence) of a concentration of one or more energy and/or mineral resources. It does not refer to or imply potential for development and/or extraction of the mineral resource(s). It does not imply that the potential concentration is or may be economic, that is, could be extracted profitably.

Appendix C

Oil and Gas Demand and Supply Relationships

The importance of potential oil and gas resources from this refuge is dependent on the hydrocarbon potential of the area, national need for additional sources of oil and gas, and the economics of exploring and producing any hydrocarbons that might be discovered. This Appendix provides a detailed review of the factors that have contributed to the present domestic oil and gas situation and possible future demand for oil and gas, which is directly linked to the national need for oil and gas resources from the refuge.

Domestic Energy Trends

The domestic energy situation, as it relates to oil and gas consumption and production, has changed dramatically since the early 1970s. In 1970, petroleum and natural gas supplied 44 and 33 percent (United States Department of Energy, Energy Information Administration, 1984), respectively, of the total energy consumed in the United States (figure 1). By 1977, petroleum accounted for nearly 49 percent of domestic energy consumption, and natural gas consumption had declined to approximately 26 percent of total energy demands. The relative contribution of both petroleum and natural gas declined through 1985, when petroleum supplied nearly 42 percent, and natural gas contributed approximately 25 percent of total energy demand. Figure 1 shows the contribution of each major primary energy source to total national energy demand in 1970, 1980, and 1985. Coal, nuclear, and geothermal energy were the primary forms of energy to increase their market share of total energy consumption during this time period, at the expense of petroleum and natural gas resources.

Total domestic energy consumption peaked at 78.9 quadrillion (QUAD) British thermal units (BTU) in 1979 and subsequently declined to 73.8 QUADS in 1985 (United States Department of Energy, Energy Information Administration, 1986). Over the 15-year period from 1970 to 1985, total primary energy consumption increased 11 percent, from 66.4 QUADS to 73.8 QUADS; however, the rapid increase in energy consumption and escalation in the cost of energy (the cost of energy more than doubled, from 1.35 constant 1972 dollar per million BTU in 1970 to 2.90 in 1981) during this time period resulted in a dramatic change in national energy consumption patterns. Total energy consumed per constant 1972 dollar of Gross National Product (GNP) ranged from 56,500 to 61,000 BTUs per 1972 dollar of GNP from 1960 through 1976 (United States Department of Energy, Energy Information Administration, 1985a). A decline in the intensity of energy utilization was realized in 1977, when total energy consumption dropped to 55,700 BTUs per dollar of GNP, and this downward trend continued through 1985, when energy consumption was reduced to 42,900 BTUs per 1972 dollar of GNP (United States Department of Energy, Energy Information

FIGURE 1
PRIMARY ENERGY CONSUMPTION BY SOURCE

FIGURE 1A
1970
Total = 65.4 Quadrillion Btu

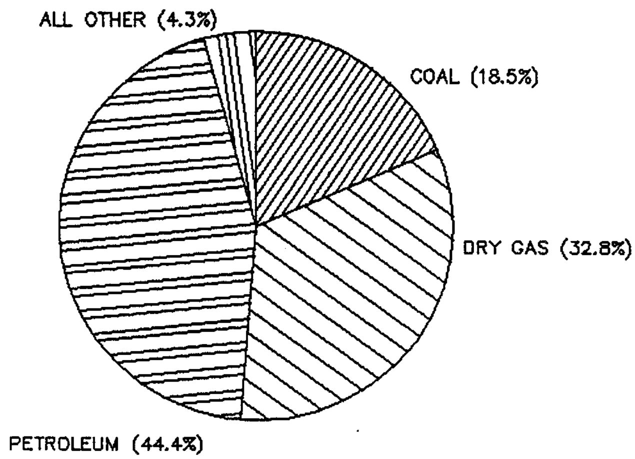


FIGURE 1B
1980
Total = 75 Quadrillion Btu

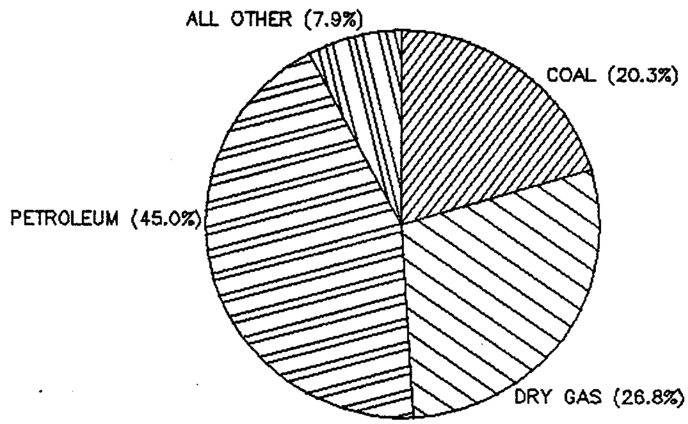
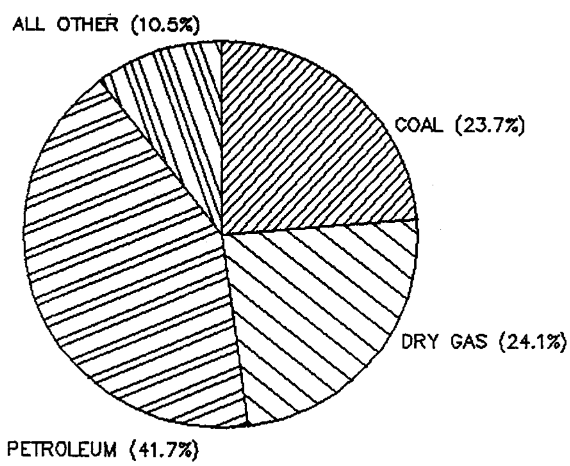


FIGURE 1C
1985
Total = 73.5 Quadrillion Btu



Administration, 1986). The decline in energy consumption was led by the reduction in the intensity of petroleum and natural gas utilization. In 1985, only 68 percent as much petroleum and natural gas were consumed per dollar of GNP than in 1977, as compared to 77 percent for total energy consumption. The reduction in intensity of energy utilization was indicative of a national conservation effort which any be attributed to many factors, including: increased real energy prices, the increased service orientation of the economy, and changes in the mix of product production (United States Department of Energy, Energy Information Administration, 1985a).

Historical Oil and Gas Demand, Supply, and Price Relationships

The relationship between price and domestic petroleum supply and demand is shown in figures 2 and 3. Import prices utilized for petroleum in figure 3 are represented by the national average refiner's acquisition cost of imported crude oil, and wellhead prices are presented on the basis of the national average from all producing wells. Domestic crude oil prices were not completely decontrolled until January 1981 and, therefore, domestic wellhead prices do not follow import prices during the 1970s. Petroleum product demand rose throughout the early 1970s, until it peaked at 18.8 million barrels per day (MBPD) in 1978 (United States Department of Energy, Energy Information Administration, 1986a). Crude oil price increases began with the Arab oil embargo in 1973, and a second major price run-up was triggered in 1978 by the Iranian revolution and subsequent oil stock building in anticipation of world oil shortages. Real import prices peaked at $44.00 per barrel (1985 dollars) in 1980.

Domestic petroleum product demand began a downward slide in 1979 which continued through 1983. The Organization of Petroleum Exporting Countries (OPEC) members sought to maintain the higher prices, that resulted from oil price shocks of the 1970s, by production restraints. However, oil prices have steadily declined since 1981 as a result of slow economic growth with subsequent declining petroleum demand and excess world productive capacity (United States Department of Energy, Energy Information Administration, 1986b). Domestic oil prices in the second quarter of 1986 had declined to the lower teens in nominal terms, which is comparable to 1974 prices in real dollars. Figures 2 and 3 show that petroleum demand is sensitive to price and is characterized by long lags and high elasticities.

Domestic petroleum production has been much more stable than petroleum product demand. Figure 2 shows that Alaskan production, primarily from the North Slope, contributes a significant portion of domestic supply. In 1986, Alaska accounted for more than 20 percent of the national crude oil production (United States Department of Energy, Energy Information Administration, 1986a). Price increases of the 1970s provided incentive for exploration and production from higher cost areas such as Alaska. Foreign imports have been required to fill the gap between domestic supply and demand. Crude oil and

FIGURE 2
NATIONAL PETROLEUM DEMAND
AND SUPPLY 1970 – 1985

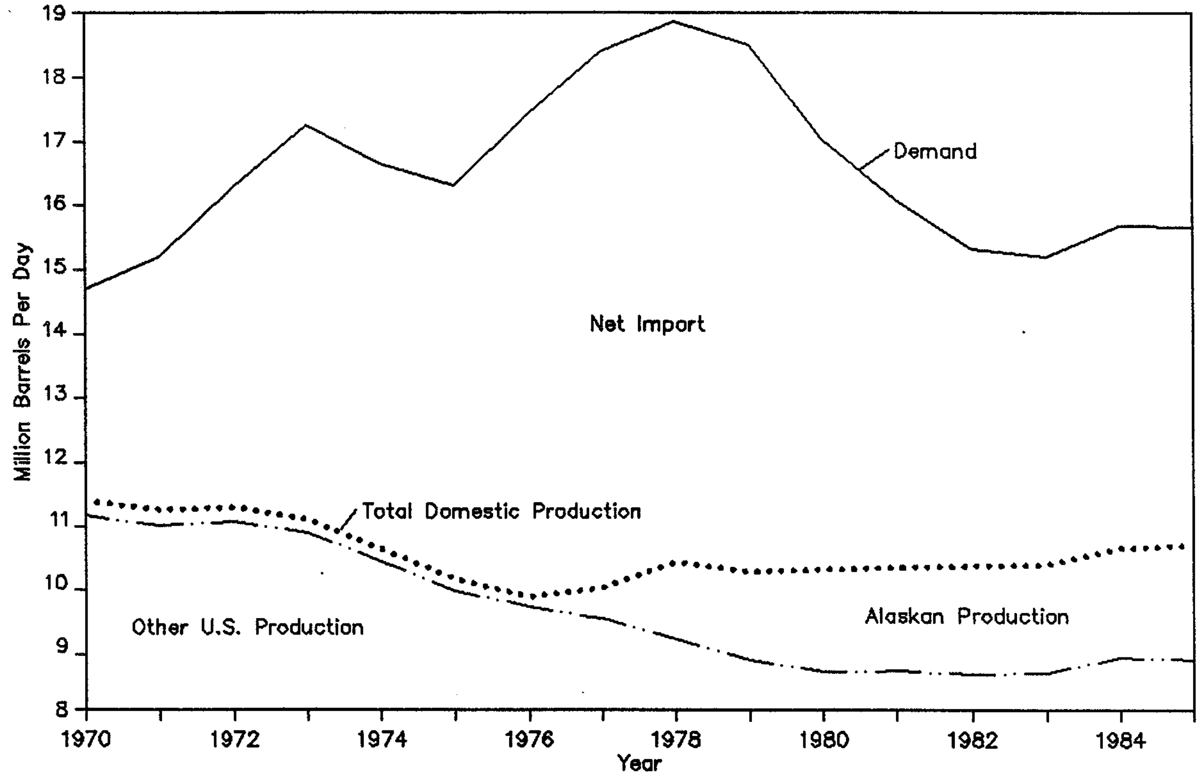
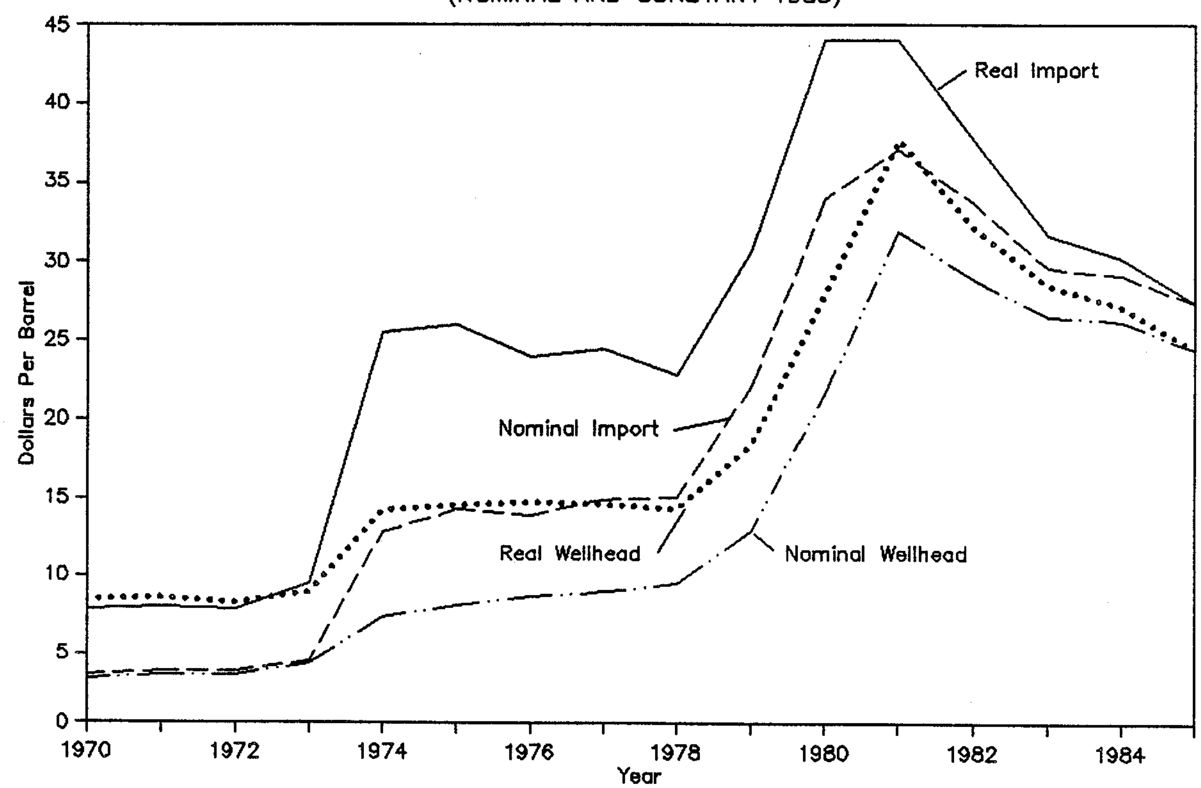


FIGURE 3
CRUDE OIL PRICES
(NOMINAL AND CONSTANT 1985)



petroleum product imports peaked in 1977, when net imports accounted for more than 46 percent of domestic petroleum consumption. Net petroleum import levels declined to 27 percent of product demand in 1985, but the United States still remains highly dependent of foreign petroleum supply sources.

The history of natural gas production and consumption in the United States is quite different from petroleum, and it has a direct bearing on gas pricing policies, demand, and supply relationships in the 1970s and 1980s (figures 4 and 5). Natural gas went from a little used waste by-product of oil production in the 1930s to a source of energy that supplied nearly 33 percent of national consumption in 1970 (figure 1). By 1970, gas was being delivered to consumers at prices well below those of competing petroleum products (United States Department of Energy, Energy Information Administration, 1984). Prices paid to gas producers by interstate pipeline companies were held at low levels through regulation by the Federal Power Commission, which resulted in increased demand and reduced incentives for producers to explore and develop new gas reserves. Regulated prices allowed intrastate transmission companies and distributors to bid natural gas supplies away from interstate carriers (Tussing and Barlow, 1984). The 1970s has been noted for the gas supply shortages in the midwest and northern states. Imported gas prices increased in a pattern similar to oil prices, but domestic prices remained under regulation. The Natural Gas Policy Act was passed in 1978, which allowed wellhead prices to increase and it deregulated certain categories of gas. Price increases provided incentives to explore and develop new sources of gas. Natural gas consumption started a sharp decline after 1980 under the influence of higher gas prices, a weak economy, warm winters, and, since 1981, falling oil prices (United States Department of Energy, Energy Information Administration, 1984). This trend continued through 1985, with the exception of a small increase in gas demand realized in 1981, which may be attributed to the strong economic growth in the national economy in that year.

Net imports of natural gas are primarily received through pipelines from Canada and Mexico, although there are some liquified natural gas (LNG) imports from Algeria. Net imports generally ranged near five percent from 1970 to 1985. Alaska is a relatively small producer of natural gas, ranging from approximately 100 to 325 billion cubic feet per year from 1970 to 1985 (United States Department of Energy, Energy Information Administration, 1985b).. Alaska is, however, a net exporter of natural gas in the form of LNG, which is delivered to Japan. Huge gas reserves have been identified on the Alaskan North Slope, but this resource has not been commercially produced due to a lack of transportation infrastructure.

Future Oil and Gas Demand, Supply, and Price Relationships

From the review of historic petroleum and natural gas price, demand, and supply relationships, it is apparent that there have been fundamental changes, such as petroleum price deregulation and energy conservation efforts in the

FIGURE 4
NATIONAL NATURAL GAS DEMAND
AND SUPPLY 1970 – 1985

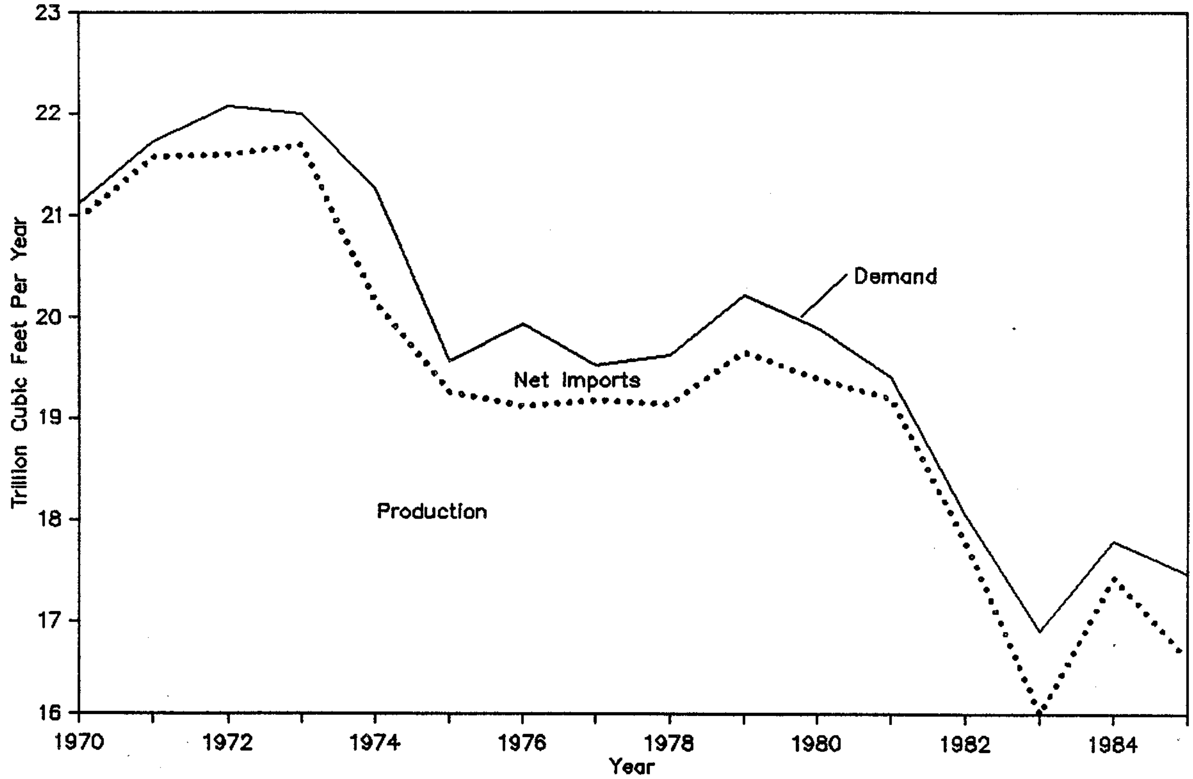
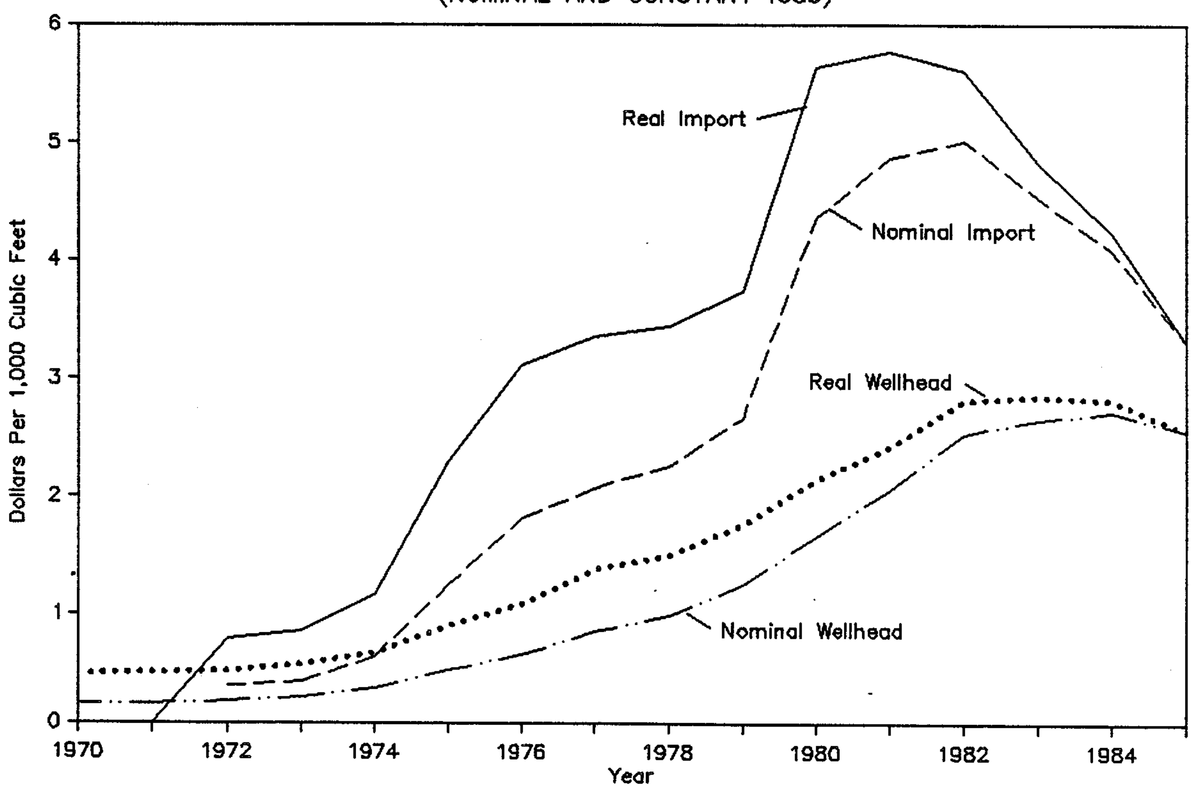


FIGURE 5
NATURAL GAS PRICES
(NOMINAL AND CONSTANT 1985)



national energy market since the early 1970s that will likely affect future petroleum and natural gas production and consumption. At the present time, the national petroleum market is directly linked to the world petroleum market by price and supply. The situation is characterized by excess productive capacity in the world market, a strong desire by exporting nations to sell petroleum to meet financial obligations, a time of relatively slow economic growth, and declining petroleum prices. The domestic natural gas industry is currently working off surplus reserves added during the early 1980s, but depressed prices have resulted in a sharp reduction in drilling which could have serious implications for future domestic gas production.

Implications of the petroleum price slide during the first half of 1986 are not yet fully discernable. Middle eastern nations have been unable to reach accord in setting and adherence to self-imposed oil production quotas. In the past, Saudi Arabia has taken the position as swing producer for OPEC, and thereby reduced production to maintain quota levels. However, Saudi Arabia changed policies in 1986 to concentrate on achieving a "fair market share" of the international petroleum market with little concern for output quotas. The strategy behind this policy was not disclosed, but speculation as to the potential motivation and results of this action includes:

1. Saudi Arabia is making a show of strength to discipline OPEC members that have cheated on production quotas and prices with hopes of bringing member and possibly non-member nations together as a unified market group;

2. Saudi Arabia sought to increase revenue, but underestimated the effects additional production would have on price;

3. Saudi Arabia is flooding the world oil market in an effort to eliminate producers with higher costs of production and thereby reduce competition;

4. Saudi Arabia is acting to reduce prices and stimulate growth in petroleum demand to reverse conservation efforts initiated in the late 1970s and 1980s.

In any event, a tremendous amount of uncertainty exists in the national petroleum industry, which has resulted in major financial restructuring. The most evident signs of restructuring are major employment reductions and reduced capital expenditures for exploration and drilling.

The interest in mineral exploration and possible development in this refuge is driven by the future national demand for oil and gas, the cost and availability of domestic supplies, and the hydrocarbon potential of the area. The rate of future economic growth and hydrocarbon prices will be the major determinants of petroleum and natural gas demand. Future domestic production is dependent on resource availability and market prices. However, political forces are having an increasingly important effect on world oil prices, which will ultimately dictate future market conditions. The instability in the world oil market results in tremendous uncertainty in predicting future hydrocarbon prices and market conditions. Table 1 presents three recent crude oil and natural gas price forecasts by the United States Department of Energy, a private research firm, and a major oil company. The prices shown in these forecasts are significantly lower than previous forecasts completed earlier in the 1980s. The range of oil prices projected in these forecasts is $18.00 to $42.00 (constant 1984 and 1985 dollars) per barrel in the year 2000. The high price range is approximately equivalent to the average annual refiner's acquisition cost of imported crude received in 1981 and 1982 (constant 1984 dollars). The range of prices projected for the year 2010 is $47.00 to $67.00 per barrel. These prices would be substantially above the peak levels paid in

Projections of future domestic petroleum and natural gas demand and supply conditions is presented in table 2. All three forecasts projected an upward trend in petroleum demand above current levels. Petroleum consumption is projected to range from 15.9 to 18.1 MBPD in the year 2000, and possibly increase to 19.4 MBPD by the year 2010. In comparison, domestic petroleum production is projected to decline to levels ranging from 6.1 to 8.9 MBPD by the year 2010. Domestic natural gas demand is projected to increase to a level ranging from 17.1 to 20.4 TCF per year by the year 2000 and then decline to a level of 16.7 to 18.3 per year by 2010. Domestic gas production is projected to follow a similar trend with domestic oil production and decline to levels ranging from 13.9 to 15.0 TCF by the year 2010.

Conclusion

National hydrocarbon markets have undergone substantial changes since the early 1970s. Energy conservation trends initiated by real price increases of the 1970s are expected to continue through the end of this decade and possibly beyond. However, future economic growth is expected to result in some increased demand for petroleum and natural gas, while domestic production of these finite resources is projected to decline. As a result, the United States will become increasingly dependent on foreign hydrocarbon sources to meet national requirements. New areas will need to be explored and any economically viable resources that are discovered will need to be brought into production in order to meet domestic needs. The potential contribution of this refuge to national oil and gas production is dependent on its resource potential and the potential cost at which any discovered hydrocarbon resources could be extracted and marketed within the constraints of future oil and gas prices.

TABLE 1

PETROLEUM AND NATURAL GAS PRICE FORECASTS[1]/

Reference	Crude Oil ($/Barrel) 1990	2000	2010	Natural Gas ($/MCF) 1990	2000	2010
U.S. Department of Energy, 1985[2]/						
Low Economic Growth	20.27	31.31	47.42	2.64	4.13	6.02
Reference Case	22.89	36.75	56.77	2.76	4.80	7.68
High Economic Growth	25.02	42.17	67.12	2.88	5.42	9.14
Data Resources Incorporated, 1986[2]/	16.91	34.32	49.99	1.69	3.80	5.76
Chevron Corporation, 1986[3]/						
Low Case	12.00	18.00	N/A	Rise to parity with fuel oil prices		
High Case	27.50	35.00	N/A			

1/ Some of the price estimates presented in this table were interpreted from graphic displays and/or extrapolated from data series, so the reported prices may vary slightly from the actual values.

2/ Reported on the basis of constant 1984 dollars.

3/ Reported on the basis of constant 1985 dollars.

TABLE 2

FUTURE DOMESTIC PETROLEUM AND NATURAL GAS DEMAND AND SUPPLY RELATIONSHIPS[1]
(See Table 1 for Price Forecasts)

Reference	Demand 1990	Demand 2000	Demand 2010	Supply 1990	Supply 2000	Supply 2010
	Petroleum (Millions of Barrels Per Day)					
U.S. Department of Energy, 1985						
Low Economic Growth	16.1	15.9	15.5	9.8	9.0	7.8
Reference Case	16.7	16.6	16.5	10.0	9.4	8.3
High Economic Growth	16.8	17.0	17.3	10.0	9.7	8.9
Data Resources Incorporated, 1986	16.9	18.1	19.4	9.5	7.3	6.1
Chevron Corporation, 1986	16.0	16.8	N/A	9.2	7.0	N/A
	Natural Gas (Trillion Cubic Feet Per Year)					
Department of Energy, 1985						
Low Economic Growth	18.6	18.8	17.2	17.4	16.1	14.7
Reference Case	19.1	19.7	17.4	17.6	16.3	15.0
High Economic Growth	19.5	20.4	18.3	17.9	16.6	14.7
Data Resources Incorporated, 1986	18.9	18.1	16.7	16.7	15.3	13.9
Chevron Corporation, 1986	17.3	17.1	N/A	N/A	N/A	N/A

1/ Some of the numeric estimates presented in this table were interpreted from graphic displays and/or extrapolated from data series, so the reported prices may vary slightly from the actual values.

APPENDIX D

Summary of Hydrocarbon Occurrence and Development Potential

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
CHUKCHI SEA UNIT (from north to south)			
Seahorse Islands	HIGH	H/C	LOW
Pt. Franklin	HIGH	H/C	LOW
Islets in west Peard Bay	HIGH	H/C	LOW
Icy Cape	HIGH	H/C	LOW
Ann Stevens/ Cape Lisburne	HIGH	H/C	LOW
Cape Thompson	HIGH	H/C	LOW
Stepping Lagoon Barrier Islands	HIGH	H/C	LOW
Tasikpak Lagoon Barrier Islands	HIGH	H/C	LOW
Pusaluk Lagoon Barrier Islands	HIGH	H/C	LOW
Tugik Lagoon Barrier Islands	HIGH	H/C	LOW
Kavrorak Lagoon Barrier Islands	HIGH	H/C	LOW
Ekichuk Lake Islands	LOW	L/A	LOW
Puffin Island	MODERATE	M/C	LOW
Chamisso Island	MODERATE	M/C	LOW

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
Sinnachiak Peninsula	LOW	L/A	LOW
Lopp Lagoon Barrier Islands	LOW	L/A	LOW
BERING SEA UNIT (north to south)			
Sledge Island	NONE	O/D	NONE
Safety Sound Barrier Island	LOW	L/A	LOW
Topkok Head	LOW	L/A	LOW
Bluff	LOW	L/A	LOW
Cape Darby	LOW	L/A	LOW
Besboro Island	LOW	L/B	LOW
Egg Island	LOW	L/B	LOW
Whale Island	LOW	L/B	LOW
Beulah Island	LOW	L/B	LOW
Cape Stephen	LOW	L/B	LOW
Sand Islands			
Krekatok Island	LOW	L/B	LOW
Neragon Island	LOW	L/B	LOW
Kikegtek Island	MODERATE	M/A	LOW
Pingurbek Island	MODERATE	M/A	LOW
Kwigluk Island	MODERATE	M/A	LOW
Hagemeister Island	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
St. Matthew Island Group			
Hall Island	NONE	O/D	NONE
St. Matthew Island	NONE	O/D	NONE
Pinnacle Island	NONE	O/D	NONE
Pribilof Islands			
St. Paul Island	NONE	O/D	NONE
Walrus Island	NONE	O/D	NONE
Otter Island	NONE	O/D	NONE
St. George Island	NONE	O/D	NONE
ALEUTIAN ISLANDS UNIT			
Near Islands			
Attu Island	NONE	O/D	NONE
Agattu Island	NONE	O/D	NONE
Alaid Island	NONE	O/D	NONE
Nizki Island	NONE	O/D	NONE
Shemya Island	NONE	O/D	NONE
Rat Islands			
Buldir Island	NONE	O/D	NONE
Kiska Island	NONE	O/D	NONE
Sobaka Rock	NONE	O/D	NONE
Little Kiska Island	NONE	O/D	NONE
Tanadak Island	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Rat Islands (cont.)</u>			
Segula Island	NONE	O/D	NONE
Khvostof Island	NONE	O/D	NONE
Pyramid Island	NONE	O/D	NONE
Davidof Island	NONE	O/D	NONE
Rat Island	NONE	O/D	NONE
Little Sitkin Island	NONE	O/D	NONE
Amchitka Island	NONE	O/D	NONE
Bird Rock	NONE	O/D	NONE
Semisopochnoi Island	NONE	O/D	NONE
<u>Delarof Islands</u>			
Amatignak Island	NONE	O/D	NONE
Tanadak Island	NONE	O/D	NONE
Ulak Island	NONE	O/D	NONE
Unalga Island	NONE	O/D	NONE
Dinkum Rocks	NONE	O/D	NONE
Kavalga Island	NONE	O/D	NONE
Gareloi Island	NONE	O/D	NONE
Ogliuga Island	NONE	O/D	NONE
Skagul Island	NONE	O/D	NONE
Tag Island	NONE	O/D	NONE
Ilak Island	NONE	O/D	NONE
Gramp Rock	NONE	O/D	NON

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Andreanof Islands</u>			
Tanaga Island	NONE	O/D	NONE
Kanaga Island	NONE	O/D	NONE
Bobrof Island	NONE	O/D	NONE
Ringgold Island	NONE	O/D	NONE
Staten Island	NONE	O/D	NONE
Argonne Island	NONE	O/D	NONE
Dora Island	NONE	O/D	NONE
North Island	NONE	O/D	NONE
South Island	NONE	O/D	NONE
Green Island	NONE	O/D	NONE
Ina Island	NONE	O/D	NONE
Crone Island	NONE	O/D	NONE
Island north of Elf	NONE	O/D	NONE
Elf Island	NONE	O/D	NONE
Adak Island	NONE	O/D	NONE
Kagalaska Island	NONE	O/D	NONE
Little Tanaga Island	NONE	O/D	NONE
Chisak Island	NONE	O/D	NONE
Umak Island	NONE	O/D	NONE
Aziak Island	NONE	O/D	NONE
Tanaklak Island	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Andreanof Islands</u> (cont.)			
Asuksak Island	NONE	O/D	NONE
Kanu Island	NONE	O/D	NONE
Tagadak Island	NONE	O/D	NONE
Great Sitkin Island	NONE	O/D	NONE
Igitkin Island	NONE	O/D	NONE
Anagaksik Island	NONE	O/D	NONE
Ulak Island	NONE	O/D	NONE
Chugul Island	NONE	O/D	NONE
Tagalk Island	NONE	O/D	NONE
Ikiginak Island	NONE	O/D	NONE
Oglodak Island	NONE	O/D	NONE
Kasatochi Island	NONE	O/D	NONE
Koniuji Island	NONE	O/D	NONE
Salt Island	NONE	O/D	NONE
Atka Island	NONE	O/D	NONE
Egg Island	NONE	O/D	NONE
Amlia Island	NONE	O/D	NONE
Sagagik Island	NONE	O/D	NONE
Tanadak Island	NONE	O/D	NONE
Agligadak Island	NONE	O/D	NONE
Seguam Island	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Islands of Four Mountains</u>			
Amukta Island	NONE	O/D	NONE
Chagulak Island	NONE	O/D	NONE
Yunaska Island	NONE	O/D	NONE
Herbert Island	NONE	O/D	NONE
Carlile Island	NONE	O/D	NONE
Chuginadak Island	NONE	O/D	NONE
Uliaga Island	NONE	O/D	NONE
Kagamil Island	NONE	O/D	NONE
<u>Fox Islands</u>			
Samalga Island	NONE	O/D	NONE
Adugak Island	NONE	O/D	NONE
Umnak Island	NONE	O/D	NONE
Vsevidof Island	NONE	O/D	NONE
Kigul Island	NONE	O/D	NONE
Ogchul Island	NONE	O/D	NONE
Pustoi Island	NONE	O/D	NONE
Emerald Island	NONE	O/D	NONE
Bogoslof Island	NONE	O/D	NONE
Fire Island	NONE	O/D	NONE
Unalaska Island	NONE	O/D	NONE
Baby Islands	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Fox Islands</u> (cont.)			
WisLOW Island	NONE	O/D	NONE
Round Island	NONE	O/D	NONE
Tanaskan Bay Islets	NONE	O/D	NONE
Dushkot Island	NONE	O/D	NONE
Erskine Bay Islets	NONE	O/D	NONE
Kisselen Bay Islets	NONE	O/D	NONE
Peter Island	NONE	O/D	NONE
Buck Island	NONE	O/D	NONE
Ogangen Island	NONE	O/D	NONE
Sedanka Island	NONE	O/D	NONE
Egg Island	NONE	O/D	NONE
Unalga Island	NONE	O/D	NONE
<u>Krenitzin Islands</u>			
Akutan Island	NONE	O/D	NONE
Akun Island	NONE	O/D	NONE
Avatanak Island	NONE	O/D	NONE
Tigalda Island	NONE	O/D	NONE
Kaligagan Island	NONE	O/D	NONE
Aiktak Island	NONE	O/D	NONE
Ugamak Island	NONE	O/D	NONE
Round Island	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
Krenitzin Islands (cont.)			
Amak Island and Sealion Rocks	NONE	O/D	NONE
Unimak Island	NONE	O/D	NONE
ALASKA PENINSULA UNIT			
Sankin Island	LOW	L/A	LOW
Sanak Islands			
Long Island	NONE	O/D	NONE
Rabbit Island	NONE	O/D	NONE
Wanda Island	NONE	O/D	NONE
Elma Island	NONE	O/D	NONE
Inikla Island	NONE	O/D	NONE
Umla Island	NONE	O/D	NONE
Caton Island	NONE	O/D	NONE
Other islets and rocks	NONE	O/D	NONE
Egg Island	NONE	O/D	NONE
Amagat Island	NONE	O/D	NONE
Sandman Reefs includes islets and rocks plus Goose, Little Goose, Midun, High, Shushilnoi, Hunt, and Umga islands	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Sanak Islands (cont.)</u>			
Sozavarika Island	NONE	O/D	NONE
Buyan Island	NONE	O/D	NONE
Patton Island	NONE	O/D	NONE
Sarana Island	NONE	O/D	NONE
Rona Island	NONE	O/D	NONE
Deer Island			
northern edge	LOW	L/A	LOW
remainder	NONE	O/D	NONE
Fox Island	NONE	O/D	NONE
<u>Pavlof Islands</u>			
Inner Iliasik Island Island			
north half	LOW	L/A	LOW
south half	NONE	O/D	NONE
Outer Iliasik Island	NONE	O/D	NONE
Goloi Island	LOW	L/A	LOW
Dolgoi Island	LOW	L/A	LOW
Poperechnoi Island	NONE	O/D	NONE
Ukolnoi Island	NONE	O/D	NONE
The Pinnacle	NONE	O/D	NONE
Wosnesenski Island	NONE	O/D	NONE
Omega Island	NONE	O/D	NONE
Kennoys Island	NONE	O/D	NONE
Jude Island	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Shumagin Islands</u>			
Unga Island	MODERATE	M/A	LOW
Gull Island	MODERATE	M/A	LOW
Egg Island	NONE	O/D	NONE
Popof Island	MODERATE	M/A	LOW
Henderson Island	MODERATE	M/A	LOW
Korovin Island	MODERATE	M/A	LOW
Guillemot Island	MODERATE	M/A	LOW
Karpa Island	NONE	O/D	NONE
Andronica Island	NONE	O/D	NONE
The Whaleback	NONE	O/D	NONE
The Haystacks	NONE	O/D	NONE
Nagai Island	NONE	O/D	NONE
John Island	NONE	O/D	NONE
Near Island	NONE	O/D	NONE
Twin Islands	NONE	O/D	NONE
Turner Island	NONE	O/D	NONE
Bendel Island	NONE	O/D	NONE
Spectacle Island	NONE	O/D	NONE
Peninsula Island	NONE	O/D	NONE
Big Koniuji Island	NONE	O/D	NONE
Castle Rock	NONE	O/D	NONE
Murre Rocks	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
Shumagen Islands (cont.)			
Hall Island	NONE	O/D	NONE
Herendeen Island	NONE	O/D	NONE
Little Koniuji Island	NONE	O/D	NONE
Atkins Island	NONE	O/D	NONE
Bird Island	NONE	O/D	NONE
Chernabura Island	NONE	O/D	NONE
Simeonof Island and islets	NONE	O/D	NONE
Simeonof Island water columns and tidelands	NONE	O/D	NONE
Chiachi Islands			
Leader Island	MODERATE	M/A	LOW
Jacob Island	MODERATE	M/A	LOW
Paul Island	MODERATE	M/A	LOW
Chiachi Island	HIGH	H/C	LOW
Chiachi Islets	HIGH	H/C	LOW
Petrel Island	HIGH	H/C	LOW
Shapka Island	NONE	O/D	NONE
Pinusuk Island	HIGH	H/C	LOW

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
Islands and capes associated with the Alaska Peninsula			
Brother Islands	HIGH	H/C	LOW
Spitz Island	NONE	O/D	NONE
Mitrofania Island	HIGH	H/C	LOW
Seal Cape	HIGH	H/C	LOW
Chankliut Island	HIGH	H/C	LOW
Gull Island	HIGH	H/C	LOW
Nakchamik Island	NONE	O/D	NONE
Kak Island	NONE	O/D	NONE
Atkulik Island	NONE	O/D	NONE
Unavikshak Islands	HIGH	H/C	LOW
Unnamed islands south of Cape Kumlik	HIGH	H/C	LOW
Kumlik Island	HIGH	H/C	LOW
Garden Island	HIGH	H/C	LOW
Eagle Island	HIGH	H/C	LOW
Sutwik Island	HIGH	H/C	LOW
Hydra Island	HIGH	H/C	LOW
Long Island	HIGH	H/C	LOW
Central Island	HIGH	H/C	LOW
Ugaiushak Island	HIGH	H/C	LOW

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Semidi Islands</u>			
Aghiyuk Island	NONE	O/D	NONE
Chowiet Island	NONE	O/D	NONE
All other islands and islets in the group	NONE	O/D	NONE
Semidi submerged lands	NONE	O/D	NONE
Chiginagak Bay Islets	HIGH	H/C	LOW
Derickson Island	HIGH	H/C	LOW
Aiugnak Columns	HIGH	H/C	LOW
David Island	HIGH	H/C	LOW
Poltava Island	HIGH	H/C	LOW
Navy Island	HIGH	H/C	LOW
Ashiiak Island	HIGH	H/C	LOW
Agripina Bay Islets	HIGH	H/C	LOW
Kilokak Rocks	HIGH	H/C	LOW
Imuya Bay Islets	HIGH	H/C	LOW
<u>Wide Bay Islands</u>			
Titcliffe Island	HIGH	H/C	LOW
Hartman Island	HIGH	H/C	LOW
Terrace Island	HIGH	H/C	LOW
West Channel Island	HIGH	H/C	LOW
East Channel Island	HIGH	H/C	LOW
Unnamed islands	HIGH	H/C	LOW

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Wide Bay Islands (cont.)</u>			
Jute Island	HIGH	H/C	LOW
Kekernoi Islets	HIGH	H/C	LOW
Alinchak Bay Islets	HIGH	H/C	LOW
Chirikof Island	LOW	L/A	LOW
Nagai Rocks	LOW	L/A	LOW
GULF OF ALASKA UNIT			
<u>Islands and submerged lands associated with Kodiak Island</u>			
Sundstrom Island	NONE	O/D	NONE
Aiktalik Island			
southeast of Aiktalik Cove	LOW	L/A	LOW
northwest of Aiktalik Cove	NONE	O/D	NONE
Geese Islands	LOW	L/A	LOW
Akhiok Island	NONE	O/D	NONE
Flat Island	LOW	L/A	LOW
Sitkalidak Island			
southeast of McDonald Lagoon and Rolling Bay	LOW	L/A	LOW
northwest of McDonald Lagoon and Rolling Bay	NONE	O/D	NONE
Fox Island	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
Islands and submerged lands associated with Kodiak Island (cont.)			
Karluk area Tidelands, submerged lands, and water column from Wolcott Reef to Stugeon Lagoon	NONE	O/D	NONE
Bear Island	NONE	O/D	NONE
Harvester Island	NONE	O/D	NONE
Noisy Island	NONE	O/D	NONE
Unnamed islands adjacent to Noisy Island	NONE	O/D	NONE
Islets at head of Northeast Arm	NONE	O/D	NONE
Sally Island	NONE	O/D	NONE
Sheep Island	NONE	O/D	NONE
Village Island	NONE	O/D	NONE
Green Island and islets	NONE	O/D	NONE
Womens Bay Islets			
Mary Island	NONE	O/D	NONE
Viesoki Island	NONE	O/D	NONE
Zaimba Island	NONE	O/D	NONE
Puffin Island	NONE	O/D	NONE
Womens Bay submerged lands, tidelands, and water column	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
Islands and submerged lands associated with Afognak Island			
Afognak submerged lands and water column	NONE	O/D	NONE
Grassy Island	NONE	O/D	NONE
Alligator Island	NONE	O/D	NONE
Rocky Island	NONE	O/D	NONE
Teck Island	NONE	O/D	NONE
Hogg Island	NONE	O/D	NONE
Bear Island	NONE	O/D	NONE
Delphin Island	NONE	O/D	NONE
Discoverer Island	NONE	O/D	NONE
Murphy Island	NONE	O/D	NONE
Sealion Rocks	NONE	O/D	NONE
Sea Otter Rocks	NONE	O/D	NONE
Latex Rocks	NONE	O/D	NONE
Dark Island	NONE	O/D	NONE
Barren Islands			
Carl Island	NONE	O/D	NONE
Ushagat Island	NONE	O/D	NONE
Sugarloaf Island	NONE	O/D	NONE
Sud Island	NONE	O/D	NONE
Nord Island	NONE	O/D	NONE
West Amatuli Island	NONE	O/D	NONE
East Amatuli Island	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
Islands and rocks in Cook Inlet			
Bruin Island	NONE	O/D	NONE
Mushroom Islets	HIGH	H/B	LOW
White Gull Island	LOW	L/A	LOW
Turtle Reef	HIGH	H/B	LOW
Iniskin Rock	HIGH	H/B	LOW
Vert Island	HIGH	H/B	LOW
Scott Island	HIGH	H/B	LOW
Iniskin Island	HIGH	H/B	LOW
Pomeroy Island	HIGH	H/B	LOW
Big Rock	HIGH	H/B	LOW
Oil Reef	HIGH	H/B	LOW
Gull Island	HIGH	H/B	LOW
Tuxedni Subunit			
Duck and Chisik islands	HIGH	H/B	LOW
Sixty Foot Rock	LOW	L/A	LOW
Chugach Islands			
Elizabeth Island	NONE	O/D	NONE
Perl Island	NONE	O/D	NONE
East Chugach Island	NONE	O/D	NONE
Perl Rock	NONE	O/D	NONE
Naguhut Rocks	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Pye Islands</u>			
Pye Reef	NONE	O/D	NONE
Outer Island	NONE	O/D	NONE
Rabbit Island	NONE	O/D	NONE
Ragged Island	NONE	O/D	NONE
<u>Chiswell Islands</u>			
Granite Island	NONE	O/D	NONE
Twin Islands	NONE	O/D	NONE
Dora Island	NONE	O/D	NONE
Harbor Island	NONE	O/D	NONE
Natoa Island	NONE	O/D	NONE
Beehive Islands	NONE	O/D	NONE
Matushka Island	NONE	O/D	NONE
Chiswell Islands	NONE	O/D	NONE
Lone Rock	NONE	O/D	NONE
Seal Rocks	NONE	O/D	NONE
Chat Island	NONE	O/D	NONE
Cheval Island	NONE	O/D	NONE
Rugged Island	NONE	O/D	NONE
Pilot Rock	NONE	O/D	NONE
Unnamed islands	NONE	O/D	NONE

REFUGE UNIT	HYDROCARBON OCCURRENCE POTENTIAL	BLM MINERAL POTENTIAL CLASS.	DEVELOPMENT POTENTIAL
<u>Other Islands of the Gulf of Alaska and Southeast</u>			
Middleton Island	LOW	L/A	LOW
Moraine Islands	HIGH	H/C	LOW
St. Lazaria Subunit	NONE	O/D	NONE
Hazy Islands	NONE	O/D	NONE
Forrester Island Subunit	NONE	O/D	NONE